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ABSTRACT

A project was designed to produce a broad description of current mining training programs and to evaluate their effectiveness with respect to reducing mine injuries. The research strategy was built on the ranking of mines according to the effectiveness of their training with an effective training effort being defined as that training which is associated with concurrent or subsequent low or reduced injury or severity rates. Aggregate training and injuries data were used to evaluate the overall training effort at 300 mines as well as specific efforts in twelve categories of training course objectives. (Data was gathered from articles in training and mining publications, telephone and mail contacts, and onsite visits to over 40 mining companies.) From such evaluations, recommendations were derived with particular emphasis being placed on identifying program characteristics that tend to be associated with effective training. Recommendations were also formulated with reference to role changes in industry and government interaction with respect to training programs, new or additional training programs, changes in the types of course materials and training methodologies, and recommendations concerning new areas of investigation. This document, the first of a two-volume report, is a summary consisting of narrative descriptions of several training programs found in the survey of the mining industry, the major results of an analysis of relationships between various measures of training and injuries, and the main conclusions and recommendations. (HD)

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Volume I, Summary

Prepared for

United States Department of the Interior
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by

Bendix
Energy, Environment,
& Technology Office
First National Bldg.
Suite 303
201 South Main
Ann Arbor, Michigan 48108

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16. Abstract

This document presents a description of the results of a project aimed at producing a broad description of current mining training programs and an evaluation of their effectiveness with respect to reducing mine injuries. Aggregate training and injury data were used to evaluate the overall training effort at 300 mines as well as specific efforts in twelve categories of training course objectives. From such evaluations, recommendations were derived with particular emphasis being placed on identifying program characteristics that tend to be associated with effective training. Recommendations were also formulated with reference to role changes in industry and government interaction with respect to training programs, new or additional training programs, changes in the types of course materials and training methodologies, and recommendations concerning new areas for investigation.

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FOREWORD

This report was prepared by the Bendix Corporation, Bendix Energy, Environment, and Technology Office, Ann Arbor, Michigan under USBM Contract Number S0144010. The contract was initiated under the Coal Mine Health and Safety Program. It was administered under the technical direction of the Pittsburgh Mining and Safety Research Center with Mr. William Wiehagen acting as the Technical Project Officer. Mr. John Blum was the Contract Administrator for the Bureau of Mines.

This report in two volumes is the final documentation of the work recently completed on the contract during the period July 1974 to November 1975. Volume I is a summary consisting of narrative description of several training programs found in a survey of the mining industry, the major results of an analysis of relationships between various measures of training and injuries, and the main conclusions and recommendations. Volume II is a more detailed discussion of the quantative data analysis and the resulting recommendations regarding a number of specific issues in the field of miner training. The draft summary volume was first submitted by the authors in July 1975, revised in September 1975, and after review by its MESA sponsors and industry representatives was resubmitted in December 1975 along with all the supporting data. This final version is limited to the summary and the complete narrative of the analysis and its implications.

We are grateful to the many individuals in government, industry, and labor for their time, interest, and inspiration for results of this review and evaluation of a very broad and complex topic.

John Adkins
Roger Akeley
Phil Chase
Leslie Marrus
William Prince
Ronald Redick
Conrad Rogne
James Saalberg
Linda Szempruch

REVIEW AND EVALUATION OF VARIOUS CURRENT MINING TRAINING PROGRAMS

FINAL REPORT

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SUMMARY

This report presents a description of the research and results of a project that was performed for the Bureau of Mines. The project objectives were to produce a broad description of current mining training programs and an evaluation of their effectiveness with respect to reducing mine injuries. The description contained in this report includes the sources and organizations of training programs and the general approaches and instructional methods used in their application. Aggregate training and injury data were used to evaluate both the overall training effort at 300 mines and specific efforts in twelve categories of training course objectives.

The research strategy was built on the ranking of mines according to the effectiveness of their training with an effective training effort being defined as that training which is associated with concurrent or subsequent low or reduced injury or severity rates. Comparisons between programs evaluated as most effective and programs which were apparently less effective were used to identify program characteristics that tend to be associated with effective rather than ineffective training.

A survey which produced the description of current mining training programs was conducted primarily via over 40 on-site visits to mining companies, schools, agencies, union representatives and MESA training facilities. In addition to collection of material and information for the summary description of training methods the survey generated several subjective insights about current programs. Compliance with the letter of the law with a minimum effort may be a superficial training objective that tends to distract from the real training program objectives of reducing injuries. First line supervisors often carry much of the training load and require real practical support. If such support is missing or consists of unrealistic expectations, his training duties will be regarded as merely annoying at best and perfunctorily carried out, if at all. Mandatory training often constitutes only a portion of the programs for indoctrination of new miners and the development of production oriented skills and knowledge.

Vocational training schools form a source of mining training that is gaining in importance and also includes the mandatory safety topics as a portion of a larger program oriented around specific occupations. This illustrates the difficulty in singling out safety as a training requirement distinct from learning to perform a job safely. The result of just doing

the minimum training needed for compliance will generally be ineffective and gain very little participation from miners who are not required to attend . Training in optional courses directed at prevention of specific types of injuries through increased awareness of the hazards involved in a job is seen as most valuable by most of the mine operators using this approach. These organizations also feel that some of the most significant benefits were gained from involving the individual miners in the development of the training program itself.

Analysis of aggregate data confirmed the overall effectiveness of the accident prevention approach to safety training. Most companies using the ground control, haulage, electrical, and general accident prevention categories of training had significant improvements to the corresponding injury rates. It was also found that the duration of reduced injury rates is only two or three quarters unless the training is repeated (not necessarily to the same miners). On the basis of examples of effective training it can be shown that the returns of reduced lost time can be very large compared to the investment in training. Ranking of mines according to the effectiveness of their overall training program found that no particular company, region, or training method will account for the variation in results. Instead there are indications that this is a function of the general level of effort devoted to training and the quality of management at the mine.

INTRODUCTION

Background

Government, industry, and labor have all given training a key role in their efforts to reduce accidents. Nearly all actions taken to reduce human error and improve worker efficiency in mining involve some form of training and education. State and Federal mine laws, the origin and growth of recent investments in training facilities and efforts and the latest UMWA-BCOA contract all reflect the importance generally given to the training of miners. This report deals with a research project that was designed to produce a broad description and approaches to the conduct of mining training programs. The project also sought to evaluate both the overall training effort and specific efforts in twelve categories of training course objectives.

The relationships between measures of training effort and injury or severity rates formed the basic evaluation criteria. Just as there are wide variations in these relationships, there are also variations in characteristics of training programs. Comparisons of programs that tend to be associated with good or steadily improving accident records with programs that appear to be less effective are used to derive recommendations concerning future action to organize, conduct, and monitor the training of miners. Two types of data were compiled in order to identify and explain variations in training program effectiveness which were obtained from existing federal and state sources. Descriptive data and information on training program characteristics were compiled by survey methods.

Quantitative Data

The Bureau of Mines Denver Office obtained aggregate data for training effort from the MESA Office of Education and Training's Qualification and Certification Unit. This Bureau office also provided us with employment, exposure, injury, and production data, covering the 1972 through mid-1974 period. These data were obtained from the MESA Health and Safety Analysis Center. Annual reports provided by several state mining departments offered a supplement to the latter data for the 1969 through 1973 period. The state report data give a baseline injury history for 110 of the 180 mines in the data that were obtained from the Bureau. They also allow a partial evaluation of training at another 120 mines not in the injury and exposure data requested from the Bureau at

the start of the survey. In all, then, 300 mines are covered by the MESA and state data.

There are three basic data sets. Two are for 180 individual mines of 43 companies or dividions covering the 1972 through mid-1974 period in three annual and ten quarterly time intervals. The third is for 230 individual mines (110 duplicate the first annual set) of 51 companies or divisions covering the 1969 through 1973 period (training data in 1972 and 1973 only). Three more sets are the aggregate company or division totals from the first three. Each of the data sets from the Bureau contains 19 measures of training and injuries plus employment, exposure, and production. Training is divided into 12 categories of course objectives and injuries are classified according to 7 combinations of accident typologies. Course objectives and accident typologies correspond as nearly as possible. The data sets derived from state sources do not include the seven accident type measures.

Aggregate Data Analysis

Analysis of the aggregate data followed two paths. The first approach consisted of a study evaluating the many cross plots of measures of training and injury rates. The plots represented various hypothetical relationships between the two rates or changes in the rates. Some of these hypotheses consider training and injuries aggregated over the same time interval (quarter or year), but most deal with either training leading to changes in injury rates or high injury rates leading to a new or increased training effort. Most of the plots of some training rate versus a subsequent injury rate find all cases falling in the triangle defined by high injury-low training, low injury-low training and high training-low injury. The substantial number of mines having low injury rates with little or no reported training stems from the fact that these mines conduct training using their own programs that are not included in the data. There are other mines that have both training and injury rates at high levels. This sort of distribution of cases on the plots can be interpreted as meaning that there are variations in the effectiveness of training just as there are variations in the amount, methods, objectives, and other characteristics of training programs. Then the aim of the aggregate data analysis is the identification of what produces effective training by a comparison of training program characteristics of two groups of mines --those which appear to be mostly effective and those in which high or increased training rates do not appear to result in reduced or continued low injury rates.

A second interpretation of the distribution of cases on the plots is that there is no systematic relationship between training and injury rates for this 300-mine cross section of the industry. However, the analysis would have to control for other major factors that are believed to influence injury rates before such a conclusion about the overall utility of training could be valid. Initial efforts to list the two groups of effective and ineffective training programs revealed another reason why more than just the bivariate plots of training and injury rates should be considered in the evaluation of training program effectiveness. Many cases of mines in the same division, seam, general vicinity, etc., were found in both the effective and ineffective lists. The available information indicated that these mines should have virtually identical training programs. Thus, the evaluations were either inaccurate or some unknown factors were behind the differences in training effectiveness. A second analysis path was adopted that sought to evaluate training effectiveness on the basis of both the levels and changes of training and injury rates over the ten quarterly and three annual time series.

This approach followed a logic that gives the highest level of effectiveness to a case of increased training rate followed by decreased injury rate where initial injury rate is already below the average for that mine, company, or division. A decrease from an above average injury rate should be easier to achieve and was therefore given a lower effectiveness score. The level of training was also considered by scoring decreased training rates the same as increases if the level remained above the mine, company, or division average. Again very few clear differences between the most and least effective training programs were revealed. Of 24 companies or divisions having 5 or more mines in the data sets, 17 had mines ranked in the top and bottom quartiles of the effectiveness index. Even though the more rigorous evaluation methods did not make it any easier to select specific programs, methods, evaluation methods or courses that tend to be associated with reduced or continued low injury rates, the close agreement between the results of all the evaluation schemes indicates that the rankings are accurate and not an artifact of any particular evaluation criterion.

In addition to evaluating overall effectiveness in terms of total employee courses versus total injuries per million man hours, the detailed time-series analyses included one other overall relationship and several relationships between a category of training objective and a type of injury. The second overall relationship used thousands of tons of production instead of millions of man hours of exposure to obtain rates. The training categories and types of injuries analyzed include:

- Ground control training versus roof and rib fall injuries
- Haulage safety training versus haulage injuries
- Electrical qualification training versus electrical injuries
- Explosives safety, ventilation, and methane detection training versus explosion and ignition injuries
- Machinery safety/qualification training versus machinery and hand tool injuries
- General accident prevention training versus total injuries and lift/pull and slip/fall injuries

Survey Data

Articles in training and mining publications, telephone and mail contacts, and visits to training facilities are the source of information on the characteristics of various training programs. The information includes course descriptions, training materials, and general organizational and procedural aspects of training at more than 50 organizations. The most detailed information came from over 40 on-site visits to mining companies (independent and captive-large and small-coal and metal/nonmetal), vocational schools and colleges, state training and mining agencies, operator association and union spokesmen, and MESA training or support facilities. Narrative trip reports and/or tabular summaries of the courses and methods employed at each source of training constitute the description of various current mining training programs. Several attempts were made to develop a format for the tabulation of this training program information that would facilitate the comparisons between the most and least effective training programs. None of these formats were considered successful because of either the wide disparity in the detail of available information or the basic differences of course organization and purposes. When the quantitative data analyses identified the difficulty in interpreting and utilizing the comparisons of training program descriptions for the most and least effective programs, no further effort was made to refine the format for tabulating this information.

TRAINING PROGRAM DESCRIPTIONS

General Observations

Responses to the survey varied in the degree of detailed information that could be obtained, but they were uniform in regard to cooperation and cordial hospitality for the survey team. Most organizations contacted were proud of their training programs and eager to discuss their achievements and problems. Only a small sample of the industry is covered by the survey, but the close correspondence of the sample and industry-wide distributions and averages for all measures indicate that it is very representative. This summary description of what the survey found begins with the general aggregate data impressions that were gained.

For obvious reasons the mandatory training administered by MESA and the MESA course materials have a nearly universal influence. There is one aspect of the nature of this influence that could be working counter to the basic reasons for having any mandatory training. This is the necessary, but sometimes confusing, strict adherence to the letter of the law in the administration of the mandatory training provisions. There seems to be a danger that technical compliance with the training effort that is required assumes more importance than the goal of reducing mine accidents. It is not something that can be measured or found in the data, but the survey team gained a distinct impression that mandatory training for miners is being treated as a legal ritual which both the operators and MESA are compelled to perform. Perhaps it would be good for mine operators and training directors to ask themselves if their operational definition of training program objectives does not go beyond remaining in compliance. There are enough cases in the data to suggest that too many high levels of training effort are associated with high and increasing injury rates because the individual mines training program might be focusing on the legal necessity rather than the hazardous work practices and attitudes that are to be found at that mine.

Another general impression concerns the central role played by the first line supervisor in most training programs conducted by mine operators. This individual is the trainee in much of the mandatory training and in terms of the certification requirements in effect at the time of the survey. He is often the instructor for training that is given the hourly employees working under him. He is the administrator of on-the-job

training; whether these programs are formally constituted and documented by the company, or if he only keeps track of each man's skill and experience in his head. He may receive substantial assistance with his training responsibilities or he may be on his own. Training should not be viewed as an annoying extra duty added to his other responsibilities for how his men work, their production, and their safety. This man, with the "toughest job in the mine" needs support (not additional duties) or else the training will tend to be performed in a hurried, perfunctory manner.

Organization

The training function is located in several places in the company organization. Large companies usually have training and education departments, with their own budget and staff reporting directly to the mine or division superintendent. There are also examples of the training staff coming under the industrial relations manager. Training and safety are sometimes combined into a single department. If they are separate organizations, training and safety will usually have equivalent status under the same company executive at all levels of management. The training director often receives support in the form of instructors and course material development from other company organizations such as safety, industrial engineering, or maintenance when the company is very large. Some large, highly structured programs focus on training equipment operators and maintenance personnel. Training department personnel deal with standard practices and company procedures for production, while the mandatory health and safety training is provided by the safety department in these programs. Such an organization may categorize the training according to its function, namely:

- Operator skills
- Maintenance skills
- Foreman/management upgrading
- Personal educational opportunity/tuition aid
- Mandatory health and safety requirements

A small mine operation usually means that the training director, safetly engineer, foreman, mine manager, superintendent, and owner

could be the same individual. Whatever formal training the small mine employees are given will tend to come from a state or MESA instructor. States having large numbers of small mines gear their training programs to serving the needs of the small operator. Nearby large mining companies are another source of mandatory training for small operators. Several small companies jointly engaging a consultant to handle their safety and training needs is an approach that might receive wider use as the mandatory training requirements increase.

Training Objectives

Review of the great number of courses, either in the MESA course materials and reporting system or given by mine operators and other training sources, made it clear that some organization for grouping courses into objective categories was needed to keep the scope of the study within reason. This project considered several options for categorizing the objectives of the various training courses and programs. For example, the mandatory and other MESA course offerings can be organized as follows:

- General Indoctrination
  - Coal Mine Health and Safety Act of 1969 (C)*
- Monitoring Mine Environment
  - Oxygen Deficiency and Methane Detection Devices (C & Q)
  - Safe Use and Care of the Flame Safety Lamp (C)

  Controlling the Mine Environment
  - Coal Mine Ventilation (C & Q)
  - Roof and Rib Control (C, Q, and A#)
- Dealing with Mine Emergencies and Accidents
  - First Aid (C & A@)
  - Use of Self Rescuer (A)
  - Principles of Mine Rescue (C)
- Operating Mining Equipment
  - Various Job Safety Guides
- Obtaining Mining Qualification or Certification
  - Electrical Safety (Q)
  - Permissible Mining Machinery (Q)
  - Man Hoisting Equipment (Q)
  - Safe Use and Handling of Explosives (Q)

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* For underground coal mines -
"C" mandatory for certified persons, "Q" mandatory for qualified persons, and "A" mandatory for all miners.

\# Instruction provided as part of mine roof control plan

@ Must be available to all miners

Only mandatory training or retraining for underground coal mines is listed in five of these six objective categories. An exception is the job safety guide category which the quantitative data shows to be seldom used. These mandatory courses are the extent of training programs for which the only real objective is to remain in compliance. More often, the program or course objective goes well beyond that and much of the mandatory training is only a part of training programs that seldom are entered into the MESA reporting system that are designed to:

- Certify new foremen in state training programs.
- Upgrade foremen skills and knowledge using company, consultant, college or vocational school, and equipment manufacturer courses on supervision, mining, or maintenance topics.
- Indoctrinate new employees using company and/or vocational school courses and facilities.
- Qualify or upgrade maintenance personnel using college, vocational school, or mining equipment manufacturer courses, course materials, or facilities.
- Improve safety records using MESA or company developed courses in accident prevention and various application of job safety analysis procedures.
- Improve the local labor base by support of college and vocational school training under associate degree or mining occupation programs.

All of the above examples of miner training find broad use and support in the industry. This is a clear indication of the belief that having more skilled miners is going to yield safer and increased production, more efficient use of supplies, better attitudes, and better supervision. The extent and way in which these categories of training are obtained by specific operators depends on each operator's view of his problem, his resources and needs for both supervisors and hourly personnel, and the availability of outside sources. The following sections of this discussion will outline the principal ways in which mandatory safety courses and production-oriented training were being carried out.

Training Sources

MESA Training Centers

The main role of MESA that emerged from the survey was one of administering the mandatory aspects of miner training and providing the course materials for these and more than a hundred additional training courses. The MESA instructors do conduct a substantial amount of training both at the training centers and at mines. However, the number of MESA instructors is such that a large percentage of the courses are conducted by MESA certified cooperative instructors (employed by the mine companies, states, colleges, or vocational schools). Training leading to certification of cooperative instructors and monitoring their performance; training in accident prevention, mine rescue, and first aid; training leading to qualification of mine electricians; providing training for mines not having certified instructors; monitoring safety records and the training performed by district mine operators; and a lot of record keeping seem to characterize typical training center activities. Their capacity to conduct more training with MESA instructors is limited by both the authorized staff levels and the fact that a well qualified instructor can earn more and spend less time on the road by working for a mine operator.

State Training Agencies

A typical state training program has its origins in state requirements for certification of foremen, shot firers, mine examiners, and hoisting engineers. During the months preceding examination for these certifications, the states conduct four to eight hours of classroom instruction per week for miners seeking the certification. The advent of the 1969 Coal Mine Health and Safety Act and the provisions for grants to state agencies to increase their miner training activities have meant that mandatory courses are being included in the programs of all ten states contacted, and most, including the two state agencies visited, offer all the mandatory courses. This training is reported to the MESA Qualification and Certification Unit in Denver via the appropriate district and subdistrict offices. Although there is some feeling by the states that MESA is intruding into an area that has long been their responsibility, good cooperation was observed at the working level. Both large and small mines utilize the services of state instructors. However, a strong commitment to assisting the small operators in their effort to comply with mandatory training was

noted. As in the case of MESA, the states have difficulty in obtaining and retaining highly qualified mining instructors.

Junior Colleges and Vocational Schools

During visits to mine operators and MESA offices some eleven junior colleges or vocational schools that offer miner training were identified, five of which were visited. This training ranged from short courses on mandatory topics to associate degree programs in mining. These programs are usually supported with funding or equipment and facilities from nearby mine operators who then use these schools in training their miners. Young men seeking careers in mining are given a basic course in mining methods, law, and safety. Next, if they desire, they continue on to mine maintenance, equipment operator, or mine supervisor programs. Naturally, there are many variations and there are some schools that specialize in only one of these career areas. The graduates tend to be highly prized as new miners and many operators would hire no others if they had any choice. There are usually agreements between the schools and mine operators not to hire students until they have completed their training. Another type of student is the miner sent to school by the mine operator as part of a maintenance apprentice program. These programs often involve alternate periods of schooling and practical work in a company shop. The main feature of the college and vocational school programs is that they have an objective of preparing a man for a career in mining. In meeting that objective the programs include required safety and qualification or certification training.

Mining Equipment Manufacturers

Training in equipment maintenance and, to a lesser degree, equipment operation is a service available from most manufacturers of mining equipment. Training materials including electrical and control station mockups, complete maintenance courses, and audio-visual aids, are also available. The training may be given on a routine basis at the manufacturer's facility or at the mine upon request. Operator personnel receiving this training are often doing so in order to teach maintenance in the company training program. Where the equipment is a special design for a unique application the manufacturer will provide demonstrations and operator training upon equipment delivery. As with the career training from colleges and vocational schools, the basic training objectives deal with production. However, safely operating or maintaining the equipment is an underlying theme in these programs.

Mine Operators

Currently the most extensive source of miner training is the mine operator. It was noted earlier that the amount of training and use of outside sources will vary with many local conditions. There are examples of operators who have a stable work force with relatively little turnover or expansion. Until the latest UMWA-BCOA agreement, these operators may have had little incentive for or perception of a need to train beyond the minimum required for compliance. At the other extreme, there are companies with high turnover or large expansion of their work force in progress. Here there seems to be a preference for using an outside training source (vocational training) if available and even creating one if necessary. Where an outside source is not practical for the training of new equipment operators and maintenance men, a few large companies are using formal on-the-job training units. Several operators believe that this approach (which gives a mixture of theory and practice in the desired safe and efficient work practices in a production environment) will be the best way to meet proposed standards for training, retaining, and certification of miners.

When viewed by an operator from the perspective of improving safety, a recurring theme in training is that analysis of accidents reveals that a large majority are caused by doing the job without regard to the hazards involved. Thus, strong emphasis will be placed on the development of task analyses and job safety guides in this training to eliminate unsafe miner practices. These programs are implemented through the unit foremen by training them in the objectives and techniques of job safety analysis and accident prevention. The foremen must then apply the techniques during scheduled safety meetings of the entire unit or some quota of "safety contacts" with individuals. Perhaps the greatest benefit from this approach is achieved when the miners themselves take part in the analysis of how they should perform their jobs safely. In doing so, they must think about and become aware of the hazards involved in their work. The entire process also gets across the message that the training is being put on because of serious company concern for the employee's health and safety. Greater attentiveness, receptiveness, and real learning will result from this realization.

Methods and Materials

The range of methods and media used to conduct miner training

extends from leaving it up to the individual to observe and learn from fellow workers to sophisticated plans for simulation of operational experience. Most mine operators recognize that the mine environment is too hazardous and unforgiving for experience alone to be the best teacher. Mining laws and safety standards exist because there are characteristics of the mining environment and operations which the miner can and should be made aware of before starting work. Some of this is knowledge that is acquired by reading a textbook, task sheet, posters, etc., or by exposure to a lecture, film, video tape, slide presentation, etc. There are also skills that must be developed by simulated experience such as testing for methane in a gas box, applying first aid techniques to a dummy or fellow students, wearing a self rescuer, traveling an escape route, testing electrical or hydraulic circuit mock-ups, and performing operational sequences of equipment in a safe non-production setting. Virtually all mandatory health and safety courses and production-oriented training are composed of some combination of knowledge and skill learning objectives. Thus, the combination of training methods and course materials come to a very large number. For each of the broad objective categories there are some patterns that were observed in the organized training programs.

New Employee Indoctrination

General indoctrination, plus monitoring the mine environment, controlling the mine environment, and dealing with mine emergencies constitute a group of course objectives that are present in miner training from the time a man is first hired through the rest of his mining career. The process begins with the personal safety equipment--hard hat, protective glasses, safety boots, leg bands, belt, and self rescuer. The new man is shown, lectured on, and issued this equipment. Use of the self rescuer is shown in film, on posters and demonstrated by each individual, and then, as shown by too many disasters, forgotten. Next comes a brief introduction to the mine environment (including the geology, mine plan, ventilation, roof control and mining methods) through lectures aided by various slides, films or tapes, posters, charts and mock-ups. This will be followed by a mine tour to illustrate and reinforce what the new man has been told by the instructor in the class room.* In one mine visited, the new miner then stays in the production setting for the rest of his training which includes company qualification for one or more production jobs over a period of six weeks.

* Some companies have the mine tour come right after personal safety equipment is issued in order to eliminate those new men who cannot personally adjust to the working environment.

Most new employee programs continue the indoctrination with lectures and demonstrations covering the topics of oxygen deficiency and methane detection devices and first aid. Films, posters, and simulation devices are used to supplement the lecture presentations and to give the student an opportunity for "hands on" experience, as feasible. More lectures from various company departments on organization and policy, and from state and union representatives on the local laws and working agreement, plus some quaification testing, will constitute the balance of new employee indoctrination. Other than exposure to slogans and either monthly (the usual case) or weekly safety meetings, the average miner will not receive any more classroom training unless he needs annual qualification or moves on to maintenance of supervision duties.

Safety Meetings

There appear to be two types of safety meetings. One, of the monthly variety, is not training but simply a meeting of management and labor representatives to discuss and otherwise resolve matters of safety at the mine. The other variety might be a weekly session conducted by the unit foreman to go over material provided by the safety and/or training department on an assigned topic. The topic and material may come from the Holmes Safety Association, the insurance carrier, or it may be developed locally to draw upon recent local experiences with hazards or improper work practices. The foreman may or may not have received some preparation from the safety or training department instructors. The talk may be preceded by a film or video tape in the bath house. It will take place at the start of the shift on Monday, in most cases, and is located in the work area. If the topic comes from one of the mandatory safety training courses, the foreman will be given a topical outline and checklist with a place for entering the names of the miners that are present. Training in some topics such as first aid refresher lessons is given by the training department instructor (s) in the same setting with appropriate training aids.

Qualification and Certification

The requirement for qualification of persons who work on electrical equipment appears to be somewhat behind the establishment of apprentice training programs for maintenance personnel. These are programs involving as much as six months of alternate periods in a classroom and working in one of the company shops. The methods again combine lecture

and testing on theory with demonstration and "hands on" experience with simulators and actual equipment. The training for certification of foremen was found to be exclusively done by the states in classroom settings at central locations in the coal fields. Entry into these programs seems to be largely a matter of individual initiative. However, the mines tend to be short of foremen and clearly do encourage participation. The classes are based on lecture and recitation methods using both standard mining texts and state-developed course materials. Other state certification programs for assistant foreman, mine examiner, shot firer, and hoisting engineer all follow the same pattern.

Supervision and Management

Programs to upgrade foreman skills in supervision and mining methods draw upon a wide variety of sources. Some lectures by management consultants may be included with presentations from other company departments such as safety, industrial relations, maintenance, or engineering. One week is a common length, but up to four weeks has been involved when enough foremen can be spared from production. In addition to various lectures, these programs include assignment to other departments for exposure to the work and problems from several perspectives. During their time in the safety department, the foremen will conduct inspections of other mines or working sections in their mines. This seems to be valuable in extending a foreman's perspective for viewing his own area of responsibility. One program that fits in the category of foreman upgrading is seeking to transfer the foreman's supervision and decision-making roles to the entire face crew. While the autonomous work group project is not strictly a training program, it is an experiment in changing miner behavior and job satisfaction that seems to be coming up with improved safety and production records. It is not mentioned here because of any unique training methods or media used, but because it illustrates the differences between training that is needed to pass some test at an arbitrary time interval and training, organizing, and leading miners to be safe, satisfied, and productive employees.

Equipment Operation

Operation of mining equipment is taught in both underground training units and in school or mine company above-ground mine mock-ups. However, these programs are relatively few in number. Most miners learn by observing other miners. When they feel ready to try a new job themselves they

will bid for the assignment when open. In some instances, these new work assignments come from the supervisor to meet a need that is filled by the most available miner (usually new) and not as the result of any planned sequence of job progression from helper to operator. When two men are needed to operate a single machine the progression from helper to operator can work for informal on-the-job training methods. This approach has both limits and the inherent danger of the helper learning bad habits from the operator. At the other extreme, the underground training unit at a large metal mine used up to three foreman as instructors per shift in an operator training program. This program begins with introduction to the basic nature of each machine, the preshift checks and maintenance, standard operating procedures, etc., and extends through actual operation of mining equipment under decreasing levels of supervision. After assignment to a production unit the new miner also must demonstrate his qualification to the unit foreman before starting out on a new equipment assignment. The methods employed here include a combination of lecture, home-work, demonstration, and practical experience. Use of combined training and production work units to provide operator training was advocated by several of the coal mine operators contacted and has been put into effect in at least one case. It has also been learned that other operators are now seeking to start such a program on a trial basis.

General

Course materials vary with the topic, as should be expected. Widespread use of MESA films, video tapes, transparencies or slides, posters, and instruction guides has already been noted. Several companies are preparing their own video tapes of lectures and demonstrations. The extensive use of films and video tapes in some programs represent attempts to compensate for the lack of qualified instructors. When this means that the desired information is being presented by the most suitable instructor, or that a larger number of miners can be reached than would otherwise be possible, there can be no argument with this use of audio-visual media. Where there is no provision for trainee response or experience and instructor feedback, simply watching a film or tape can easily be a waste of time. The provision for response can be relatively simple. A checklist or list of questions along with the appropriate apparatus for demonstration by the person leading the follow-up discussion is apparently successful. Training aids for first aid courses are numerous and are frequently employed, especially devices for gaining experience in artificial respiration. A glass roofed mine model is

often used to illustrate the methods of mine ventilation. Other mockups observed included devices to illustrate articulated steering, effects of changing the center of gravity of loaded equipment, and the logic for drilling patterns and shot sequence.

Mining law and company safety or operating standards are frequently printed in pocket-sized pamphlets given to all employees. Many are illustrated with cartoons showing the results of improper work practices. This tends to be the extent of the material given the hourly employee for home study. Other more elaborate self-study materials were not observed during this survey, although it is known that various self-paced training courses are being developed. No one contacted expected that any form of home study will gain widespread acceptance and use. Many, however, did agree that any approach to training that would get the attention of more miners would be worth trying.

Instructors

As with any effort to pass information from one person to another, the success of teaching mine safety is highly dependent on the characteristics of the instructor. In order to impart knowledge and to develop attitudes favoring safe work practices, an instructor must be well-versed in both the subject matter (technical skills plus experience) and in the techniques of transmitting the knowledge and attitudes necessary to instill safe work habits. The technical skills and experience of the instructors observed in the survey were uniformly high. Many were former foremen or managers and their backgrounds satisfy the requirement of knowing the subject matter. Transmittal or teaching skills were more difficult to assess than were background characteristics. One general observation is that instructional skills seem to be less well-developed than are technical skills. Similarly, teaching skills seem to be less uniform from instructor to instructor.

In most cases, instructors were experienced miners or experienced in their technical field (e.g., electricity or hydraulics). The length of time each had worked as a miner and the jobs each performed varied widely, but all those who had some firsthand experience with mining had been foremen or engineers. Most state instructors and a number of the instructors in larger coal companies had been active in the mining industry in other capacities. Many instructors in formal training programs were MESA certified. Night program instructors at vocational schools

tended to be men working in supervisory or engineering pos itions at nearby mines.

In the case of on-the-job training, the instructor's background is more difficult to determine since such training is usually carried out by the miner's immediate supervisor. The foreman responsible for on-the-job training of a new man or man changing jobs will usually assign this trainee to work with an experienced miner. This arrangement, of course, allows a great deal of flexibility in the length and style of the instruction and certainly provides one of the best student to teacher ratios (usually one to one). Unfortunately, the approach also allows for a great deal of inconsistency in the quality of the instruction. Unsafe work habits can be transmitted as easily as proper ones and indifferent, if not negative, attitudes toward safety precautions are often passed from old to new miners via on-the-job sessions. The problem is not that on-the-job training is inherently bad or even deficient, it is merely inconsistent from case to case and very difficult to monitor and correct or improve when it is inade quate. On-the-job training can be strengthened by use of check-off lists to note progress and insure that a minimum of topics will be covered.

Foremen usually provide most of the safety training per se. Such training usually consists of the mandatory safety instruction plus occasional topics chosen by the foreman himself or other mine officials, depending on local custom. Safety officers often try to use recent and known mine accidents as the basis of lessons for the regularly scheduled safety meetings. When a mine had designated safety officer, he was found to be in communication with his counterparts from other mines and state and federal agencies. Encouragement for sharing of ideas and approaches to safety programs via private associational activity and for state or federally sponsored workshops and conventions is going on in some regions. These efforts need to be nurtured and should focus more attention on instructional approaches and motivational techniques.

Motivation

The term motivation refers to the whole spectrum of efforts made to make the individual miner aware of the hazards involved in his work and how to avoid accidents and injury. These efforts can even begin with training given the miner before he is hired. Pre-employment vocational training programs for the young man seeking a mining career will usually

guarantee a graduate a good job with a mining company or a mining equipment manufacturer. Hence, there is some built-in motivation to take advantage of this type of training, including the safety training offered. Some problems do arise when the graduate is not able to bid on jobs for which he has been trained in school because of union seniority bidding procedures. Consequently, bidding policies can have a negative impact on the motivation of a young person to seek vocational training for a mining career, unless the training can be integrated into a work-study program that provides for building up both the needed skills and seniority at the same time.

Safe work motivation techniques used by companies to improve the safety records of their operation can be conveniently put into one of three categories. These are the safety consciouness raising efforts, the reward incentives programs, and the organizational change approaches. The first two use a series of "gimmicks" (no negative connotations are to be implied) in order to make the miner more aware of hazards, and to think positively about work practices that avoid these hazards. These programs may consist of signs, posters, decals, and verbal communications (both personal and radio messages) designed to stimulate thought about safe work habits.

Closely linked to the advertising approach, is the incentive-reward approach. In this case the miner is rewarded for periods of accident free work. The rewards range from bonus pay to trading stamps. Some companies give discounts on safety shoes and boots or other goods to workers with good safety records. Prizes may be given to the wives of employees who know the current safety slogan. Family participation has been found to be an important source of miner motivation and is encouraged by companies through such efforts as giving prizes to miners children for creating the monthly safety slogan or poster and sponsoring annual safety banquets or picnics. Negative reactions and miner resentment to involving families was cited by few of the companies surveyed. This seems to stem from strong adversary feelings between management and labor where the prizes are seen by the miner as an attempt to shift his loyalty rather than induce him to work safely.

The third category consists of those efforts made to increase safety and production by making changes in the actual organization of production operations. These efforts are experimental and limited to a few companies and usually to a portion of the total work force. In its simplest form, the approach consists of efforts to train foremen in better leadership techniques. The more sophisticated techniques employ efforts to develop

new and more satisfying roles for both the foremen and the workers, to improve communication between the foreman and his men and to involve the men more directly in the decision-making process of the company, particularly in regard to safe work practices.

On an even more limited scale, experiments are being conducted in which the entire organization of production is being altered. While such programs are few in number, they deserve attention because of their potential pay-off to the coal industry and because they are now being paralleled with new organizational techniques being tested in many other parts of private enterprise, education, and government; particularly the military.

The underlying theme of these efforts is the increased independence and responsibility of the individual work groups in the mine. The thesis is that increased productivity and safety will be realized by developing a production organization that allows the work group maximum autonomy in its operation. In some cases, in exchange for greatly reduced company supervision and direction, the work group relinquishes its grievance procedure, taking on the responsibility to solve its own problems. Obviously, initiating such programs requires a great deal of cooperation and support, from both union and management.

The benefits from these programs have been demonstrated in the experimental cases but they are too few and too new to have yet been adequately evaluated as a possible course for a large portion of the coal industry to adopt in its effort to improve both production and safety.

Follow-up Survey

Upon completion of the draft summary report, copies were sent to organizations cooperating in the survey for review. Plots of several relationships between training and injuries showing individual mines and company or division results were sent to mining companies along with the appropriate survey narrative. In general, this review did not disclose the need for revision of the training program descriptions, analysis findings, or recommendations. Five elements of new information were turned up that will be added to this summary.

Mine management and leadership emerge as a dominant theme in the follow-up discussions. Training for supervisors in leadership and communications skills is now available from several commercial and academic institutions. Numerous examples of mine operators who are seeking solutions to their labor, productivity, and safety problems through use of this type of training can now be identified. Some appear to be well satisfied with the results obtained, however, no rigorous

evaluation is possible. Operator skill training in either underground or simulator environments for coal mining still appears to be limited to providing a fixed amount of exposure and hands on experience without testing the trainee skill relative to some "production standard" as was found in a large metal mine. Check lists and safe job procedures developed for formalizing on-the-job training are very detailed and complete. So detailed, in fact, that one may question whether they reflect the normal work procedures that are followed. For example, the time planned for roof bolting in the "typical" production cycle and observed in various time studies is not realistic if the bolter were to perform every step on the "approved procedure." Care must be taken to avoid training one thing while demanding another when actually engaged in mining.

More and more vocational-technical schools that are just starting to offer miner training or have been doing so under state or HEW Office of Education support turn up as time passes. The content of these programs varies with local needs. Maintenance training appears to be a dominant topic. This probably reflects the fact that maintenance man apprentice or trainee has been a easily defined job bidding opportunity. The provision for formal skill training and standards for other mine occupations will probably lead to greater involvement of vocational-technical schools in the area of equipment operation. The most effective use of this training resource seems to be in the provision of training in the skills needed in a miners next job rather than a one or more year sampling of all the skills and knowledge that can be assembled on the subject of mining. There is a need for management and labor to agree on more than just a need for training now if the time and resources devoted to training are going to efficiently produce more and safer miners to meet the needs of likely industry expansion.

Finally, the fact that interpretations of first aid and lost time injuries do vary was called to our attention. Analysis that compares the injury rates reported by one company with another company or mine will, of course, be biased accordingly. However, our main concern in the quantitative data analysis is with the change over time within a reporting unit. Evaluations of effectiveness were therefore not biased by mine to mine variation in what gets reported. At the same time the available data is limited by its apparent quality and a lack of common definition between reports of accidents and training whose objective may be reduction of accidents.

ANALYSIS AND EVALUATION

Overview

Study of the relationships between total training effort and overall accident records centered on two pairs of measures. Total injuries per million man hours versus total employee-courses per million man hours is the first relationship. The second is total lost days per 1,000 tons versus total employee-courses per 1,000 tons. Both give essentially the same results for identification of effective and ineffective training, but the latter is of interest because it can be rescaled to represent a comparison of the production "costs" of accidents and training.

The analysis has included both the 300 individual mines and aggregate scores for companies or divisions. Quarterly and annual time intervals have been used. Time lags between training and injury rates (and the reverse) of zero, one, and two quarters or years were considered. Cross plots were studied for 25 possible hypotheses for the relationship between levels of, or changes to, training rates and levels of, or changes to, injury rates. Because all the training has not been uniformly effective and because many factors other than training also influence injury rates, these plots were not expected to either prove or disprove any of the hypotheses. Finding clusters or bands inferring some systematic distinction between groups of mines would have been useful for the derivation of recommendations concerning the nature of the training effort needed for effective training. No simple formulas for effective training are to be found in either the hundreds of plots or in the identities of mines, companies, or divisions that fall within the two areas of the plots that could be defined as effective or ineffective. The general nature of how total training and total injuries have varied in the 300 mine cross section of the industry is summarized below by some tables and examples of plots.

Although study of the plots found evidence that high and increasing training rates are generally associated with low or improving injury rates, it was also found that the evaluation criterion should consider more than just one or two points in time. A more detailed study of the entire time series data using both quarterly and annual aggregations sought to improve the classification of programs into effective and ineffective groups. Each mine, company, or division was given a weighted score for each period of training (quarter or year) based on:

- Training rates in that and the previous period and the average training rate for the 1972-1974 interval.

- Injury rates in that and the following period and the average injury rate for that mine, company, or division.

The average score or "effectiveness index" was used to rank the mines or companies and divisions into approximate quartiles. Cases in the top and bottom quartiles agree well with the results obtained from the bivariate plots. The main difference is that slight decreases in training rates and slight increases of injury rates are not arbitrarily excluded from the evaluation or considered ineffective.

Comparison of training program descriptive information for mines apparently having the most and least effective training was not able to show that any particular training method or procedure is more effective than another. There are simply too many examples of all approaches to training that can be found near the top and bottom of the effectiveness rankings to be able to associate one characteristic with success any more than another. Nor is type of company, mine, seam, or location of any importance in accounting for a mine's ranking in training effectiveness. Examination of the mix of training effort between the several categories of course objectives did reveal some important distinctions. The ratio of instructors to employees and also the percentage of quarters in which training was given show the greatest differences between the most and least effective training programs. Finally, an example of how effective training can reduce lost day rates was developed.

Total Training Versus Total Injuries

Plots of Lost Days Per 1,000 Tons Versus Employee-Courses Per 1,000 Tons

The examples of the results of plotting a measure of training rate versus a measure of injury rate are drawn from the work done by using production as a basis for the rates. These were selected since both lost days and employee-courses can easily be interpreted as costs. Figures 1 and 2 are plots of the changes in the lost day rate from 1972 to 1973 and from 1973 to 1974 versus the change in the training rate between 1972 and 1973.* These plots use a logarithmic scale to facilitate identification of the large number of the 140 mines that had relatively small

*The differences were obtained so that positive values represent improvement to lost day rates and increases in training rates.

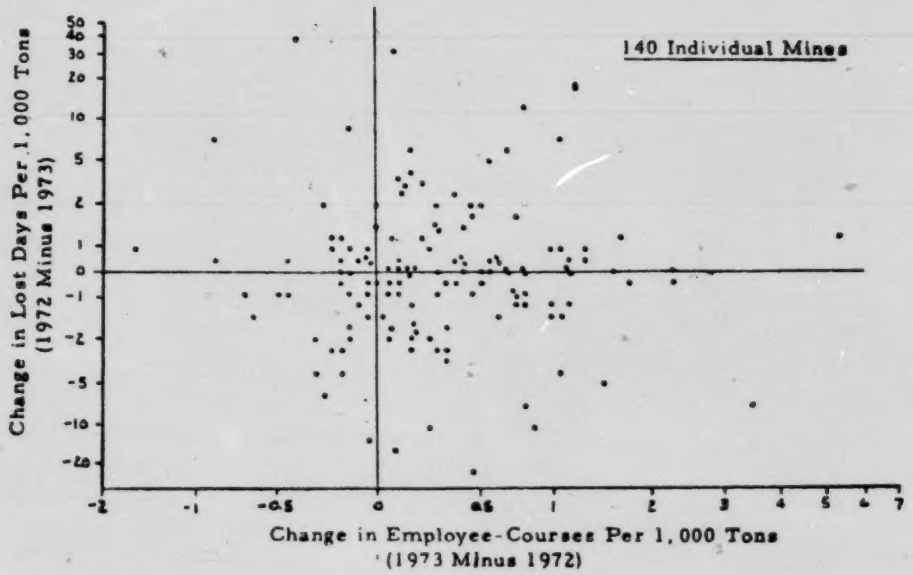

140 Individual Mines
Change in Lost Days Per 1,000 Tons
(1972 Minus 1973)
Change in Employee-Courses Per 1,000 Tons
(1973 Minus 1972)

Figure 1

Changes in Lost Day and Training Rates
without Time Lag

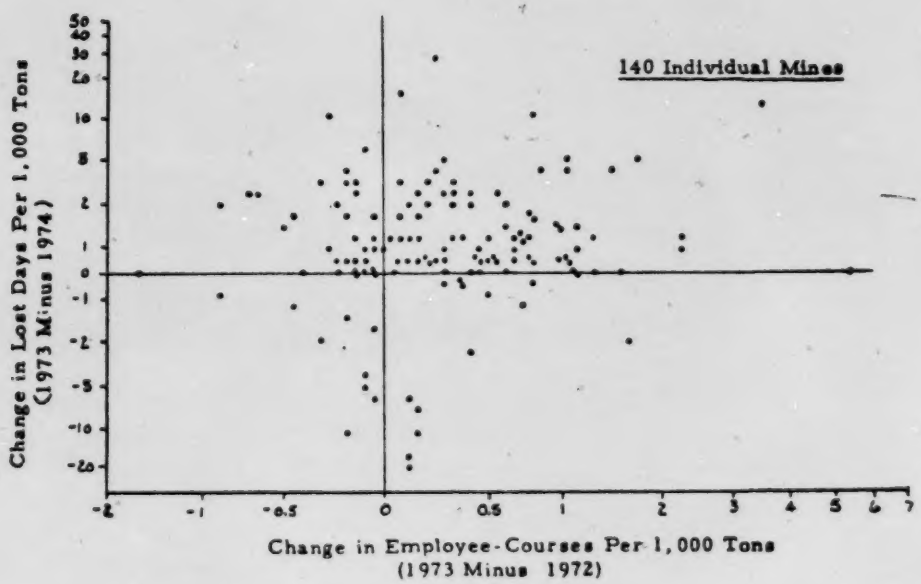

140 Individual Mines
Change in Lost Days Per 1,000 Tons
(1973 Minus 1974)
Change in Employee-Courses Per 1,000 Tons
(1973 Minus 1972)

Figure 2

Changes in Lost Day and Training Rates
with Lost Day Rate Lagged

changes. The right hand sides of these plots show the 96 mines that increased their 1973 rate of training over their 1972 training rate. In 1973 only 44 of those 96 mines had a decrease in the lost day rate from 1972 levels. Looking ahead a year finds 79 of the 96 mines had improved lost day rates. Not shown in these plots is the fact that some 55 of the 96 miners increased their training rate again in 1974 and this seems to explain 26 of the 47 cases of lost day rate improvement in 1974 but not 1973. Of the 44 cases of decreased lost day rate in 1973 only 12 changed to increases in 1974 even though all but one of these are associated with continued increase in training rate in 1974. Of 44 mines that decreased their training rate in 1973 only 12 had improved lost day rates in both 1973 and 1974. All of these 12 mines had relatively high training rates in 1972 and all are part of large companies that have active safety programs that do not show up in the MESA training data. Another 22 of the 44 mines with a decreased 1973 training rate had lost day rate improvements in either 1973 or 1974. Again, these can be associated with very high 1972 training rates or an increase in the 1974 training rate. In summary, nearly all the improvements to lost day rates can be related to a high or increased training rate. Study of 31 increases to lost day rate in 1974 finds only 15 cases of increased training in 1973 to 74 that might be termed "ineffective." This says a great deal for the overall effectiveness of training, but these findings cannot be derived from study of any single pair of training and injury rate observations.

A second way of viewing the data presented in figures 1 and 2 is to divide the change in training rate into quartiles and determine what proportion of mines in each quartile had improved lost day rates in 1973 or 1974. Lost day rate improvements associated with 1974 training rate increases should be excluded and were when the distinction was possible. Table 1 lists the results of this tabulation of changes.

TABLE 1

PERCENT DECREASED LOST DAY RATE BY QUARTILE OF THE 1972 TO 1973 CHANGE OF TRAINING RATE

Year of Lost Day Rate Decrease	Quartile of Change of Training Rate (Greatest increase to greatest decrease)			
	First	Second	Third	Fourth
1973	40	54	50	47
1974	86	86	61	35
Both	31	43	17	23

There is a fairly clear indication from the 86 percent improvements in 1974 for the two quartiles of greatest increase in training that increased training is more likely to be associated with improved lost day rates than is decreased training. But it is also clear that the evaluation needs to consider more than just the changes in order to accurately rate the effectiveness of the various training programs. This can be seen from the proportion of mines with a decreased yet still quite high training rate in 1973 that is associated with improved lost day rates in 1973 and 1974. The next set of plots will deal with both levels and changes in training and injury rates over the 1972 to mid-1974 period.

The 140 mines in the plots of Figures 1 and 2 represent 43 companies or divisions ranging from 1 to 30 mines. The aggregate company and division lost day and training rates and annual changes are plotted in Figures 3 through 11. Figures 3 and 4 are the cross plots of the two annual changes of the rates without time lags and with the lost day rate change lagged one year as in Figures 1 and 2. Figures 5, 6, and 7 are cross plots of the same change of training rate from 1972 to 1973 versus the lost day rates in 1972, 1973 and 1974, respectively. Finally, the last four plots 9 through 11, pull all the information together by showing the 1972 training rates versus 1973 lost day rates and 1973 training rates versus 1974 lost day rates. Figure 8 shows all cases while Figures 9 through 11 give the examples of effective and ineffective cases of increased training and the cases of decreased training. Of the 43 companies or divisions:

- 19 experienced an improved lost day rate in 1973 with the median change being a 0.25 day/1,000 tons increase.
- 29 experienced an improved lost day rate in 1974 with the median change being a 0.45 day/1,000 tons decline.
- 12 experienced declines in both 1973 and 1974.
- 8 experienced increases in both 1973 and 1974.
- 33 increased 1973 training rates over the 1972 levels with the median change being a 0.50 employee-course/1000 tons increase.

Dividing the change of training rate into quartiles gives three ranges of increased training of 11 cases each and 10 cases of decreased training. In each quartile the changes that took place were:

- Largest increase in training rate (11 cases) --
  - 5 improved lost day rates in 1973.
  - 3 of those 5 improved again in 1974.
  - 4 cases shifted from increase in 1973 lost day rate over 1972 to a 1974 improvement (decrease).

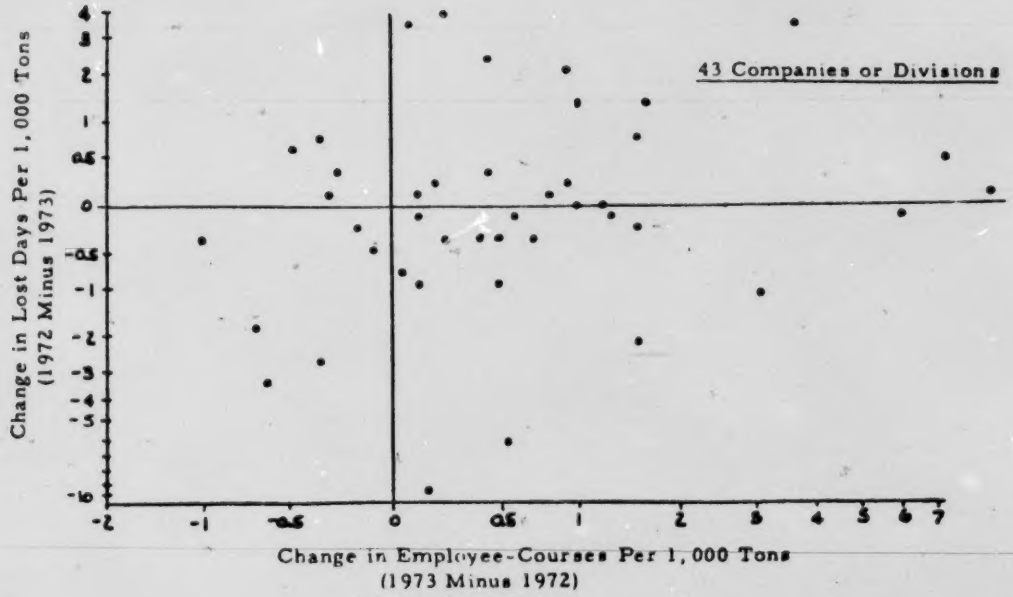

43 Companies or Divisions
Change in Lost Days Per 1,000 Tons
(1972 Minus 1973)
Change in Employee-Courses Per 1,000 Tons
(1973 Minus 1972)

Figure 3

Changes in Lost Day and Training Rates
without Time Lag

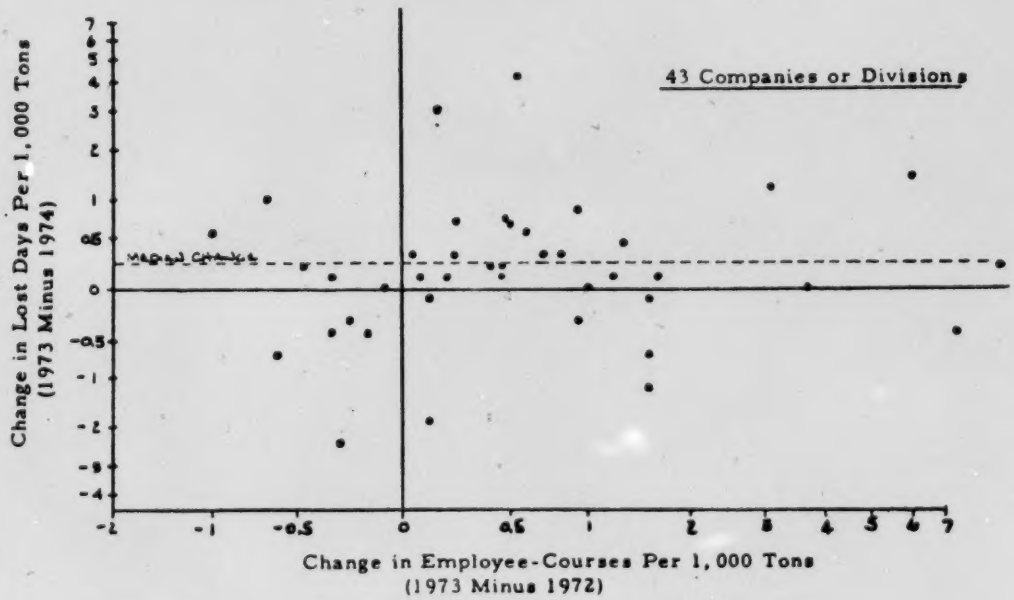

43 Companies or Divisions
Change in Lost Days Per 1,000 Tons
(1973 Minus 1974)
Change in Employee-Courses Per 1,000 Tons
(1973 Minus 1972)

Figure 4

Changes in Lost Day and Training Rates
with Lost Day Rate Lagged

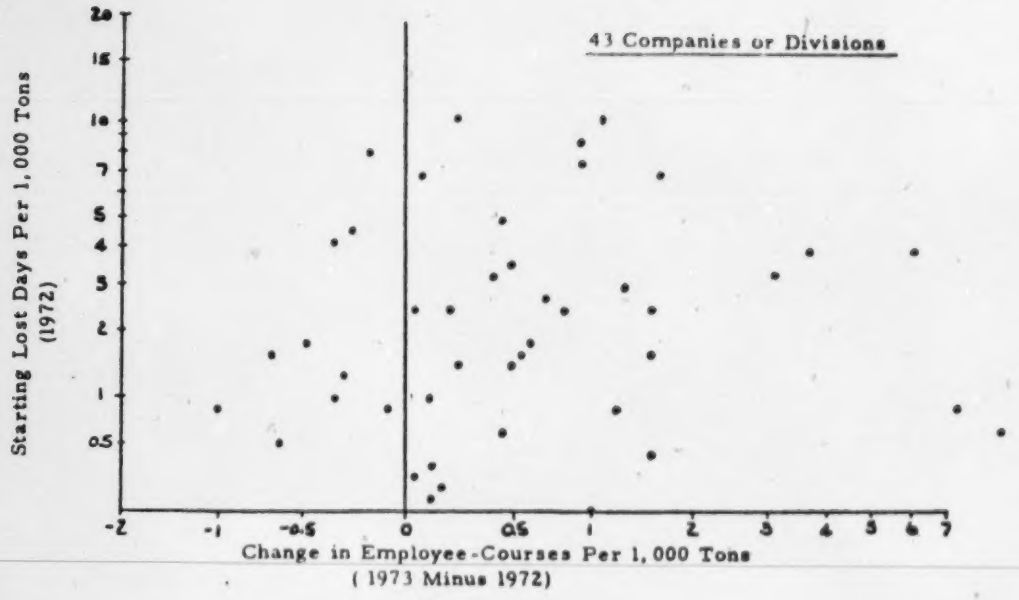


Figure 5

Starting Lost Day Rate and Change in Training Rate

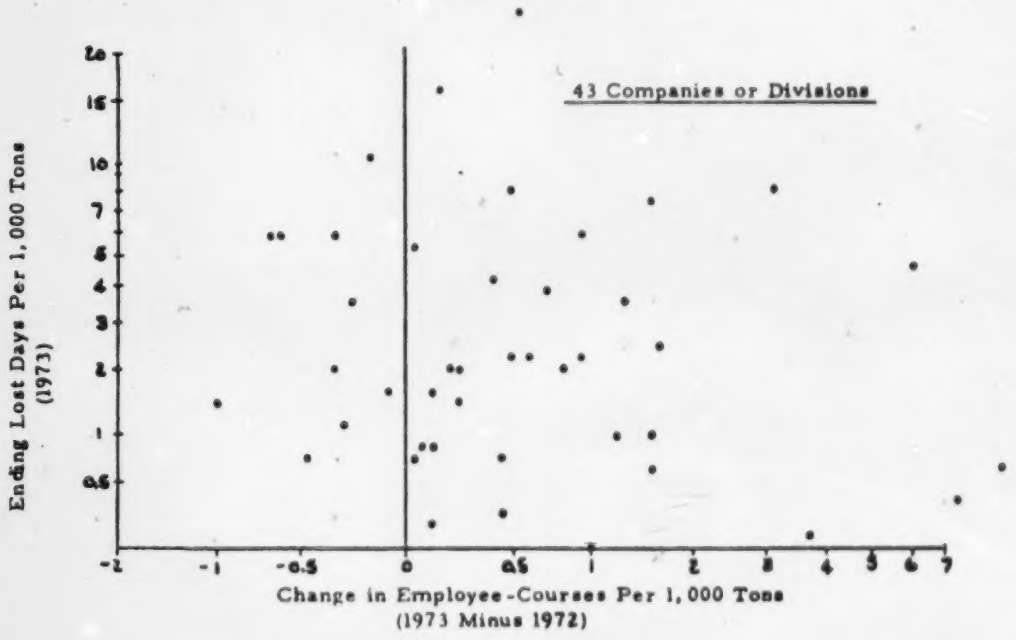


Figure 6

Ending Lost Day Rate and Change in Training Rate

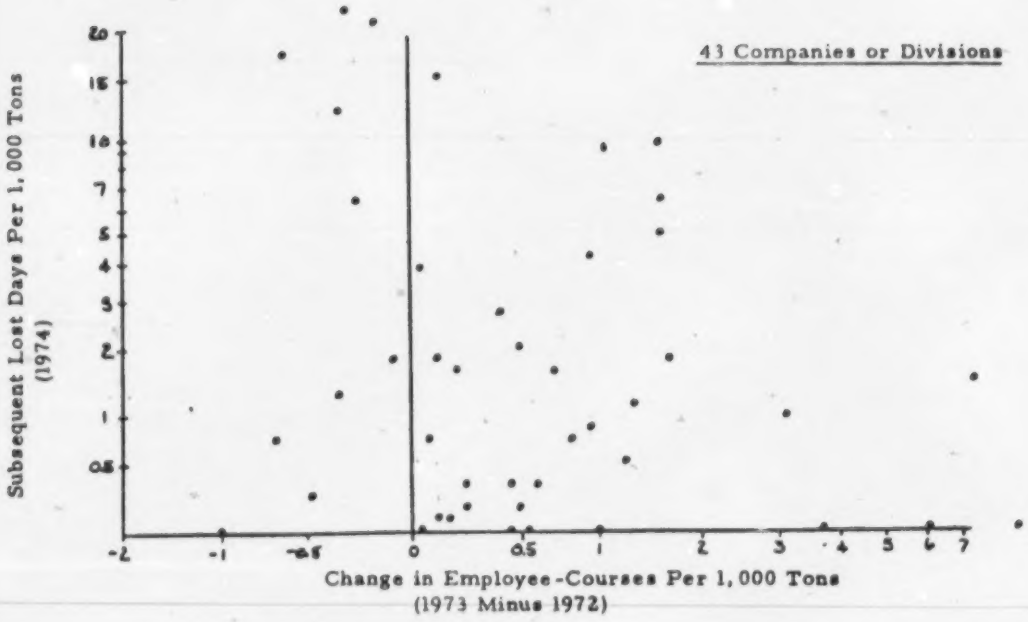

43 Companies or Divisions
Subsequent Lost Days Per 1,000 Tons
(1974)
Change in Employee-Courses Per 1,000 Tons
(1973 Minus 1972)

Figure 7

Subsequent Lost Day Rate and Change in Training Rate

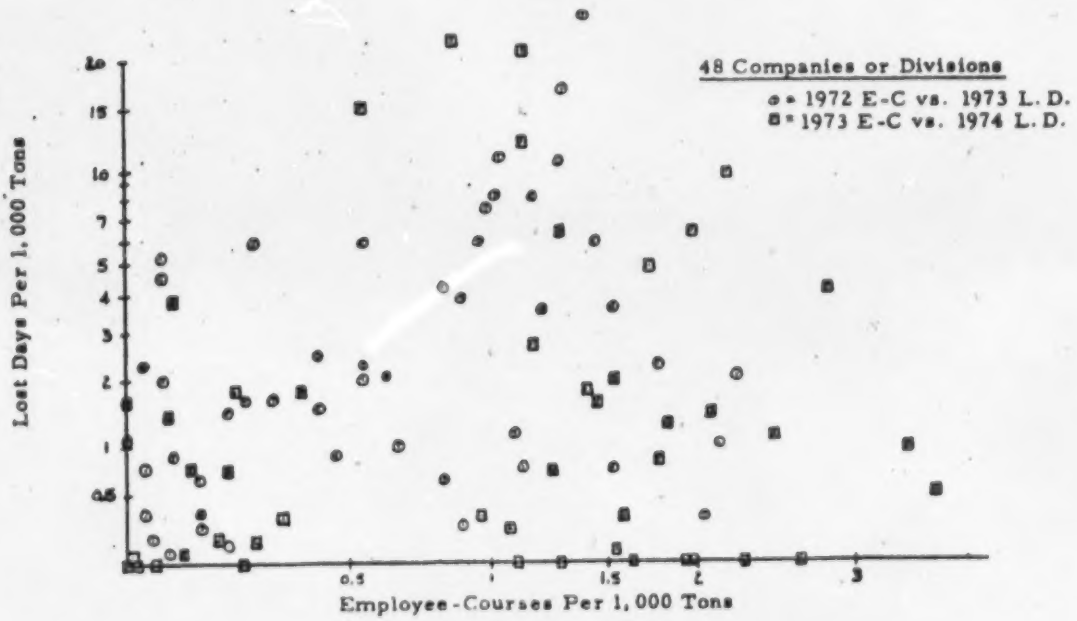


Figure 8

Training Rates Versus Lagged Lost Day Rates

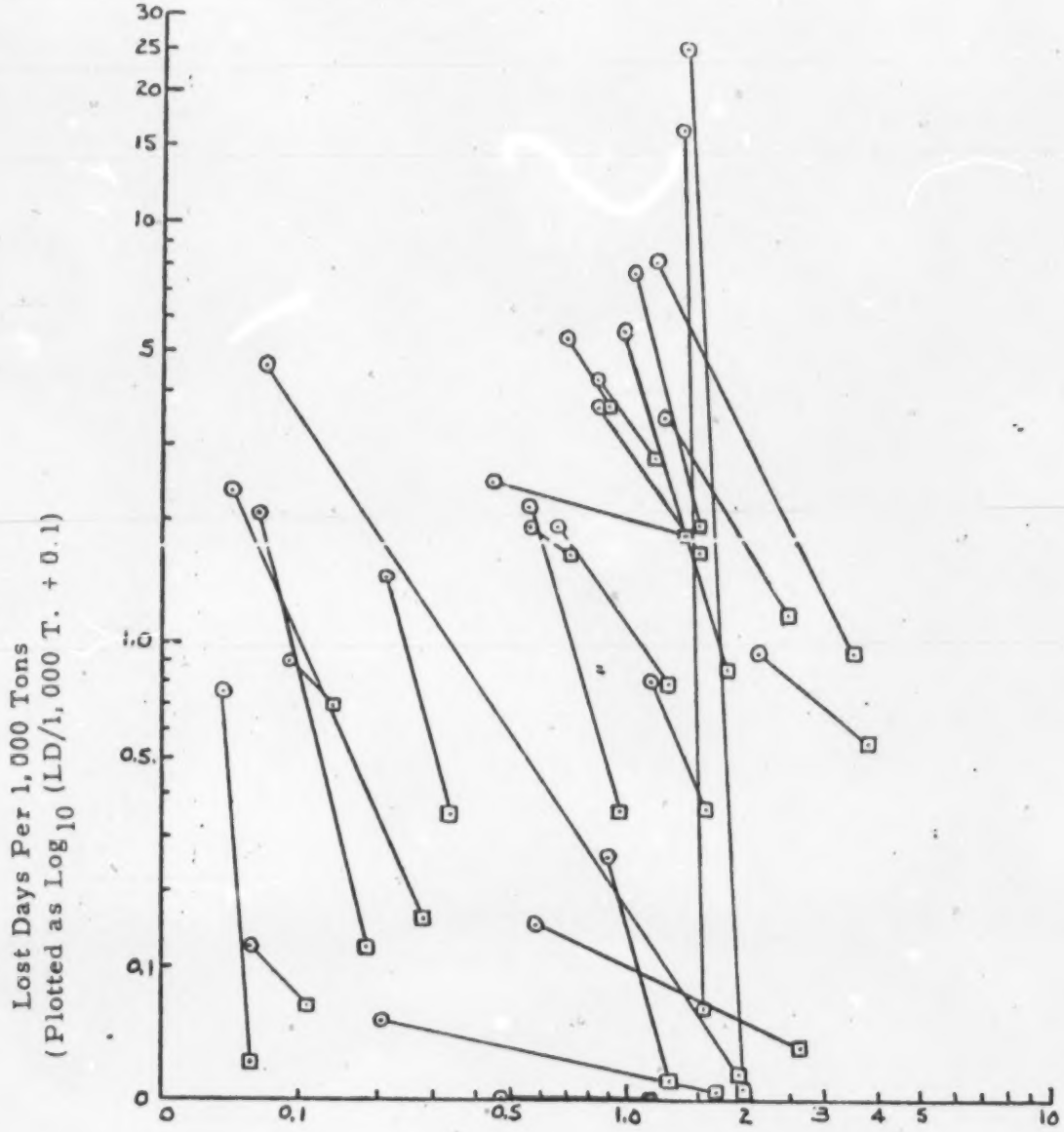
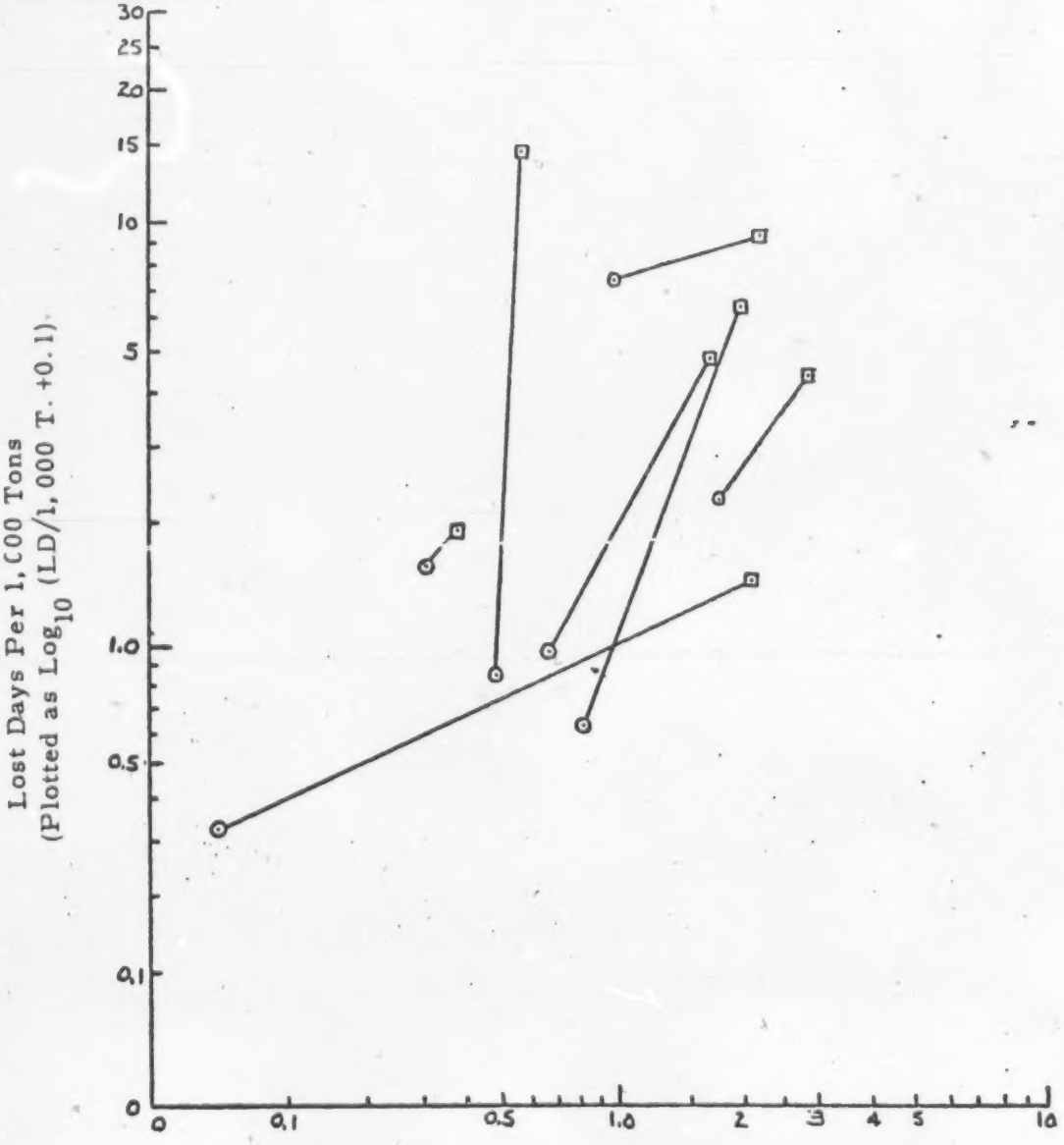


Figure 9

Examples of Effective Training



⊙ = '72 Empl-Cse/1,000 T. vs. '73 Lost Days/1,000 T.
⊡ = '73 Empl-Cse/1,000 T. vs. '74 Lost Days/1,000 T.

Figure 10

Examples of Ineffective Training

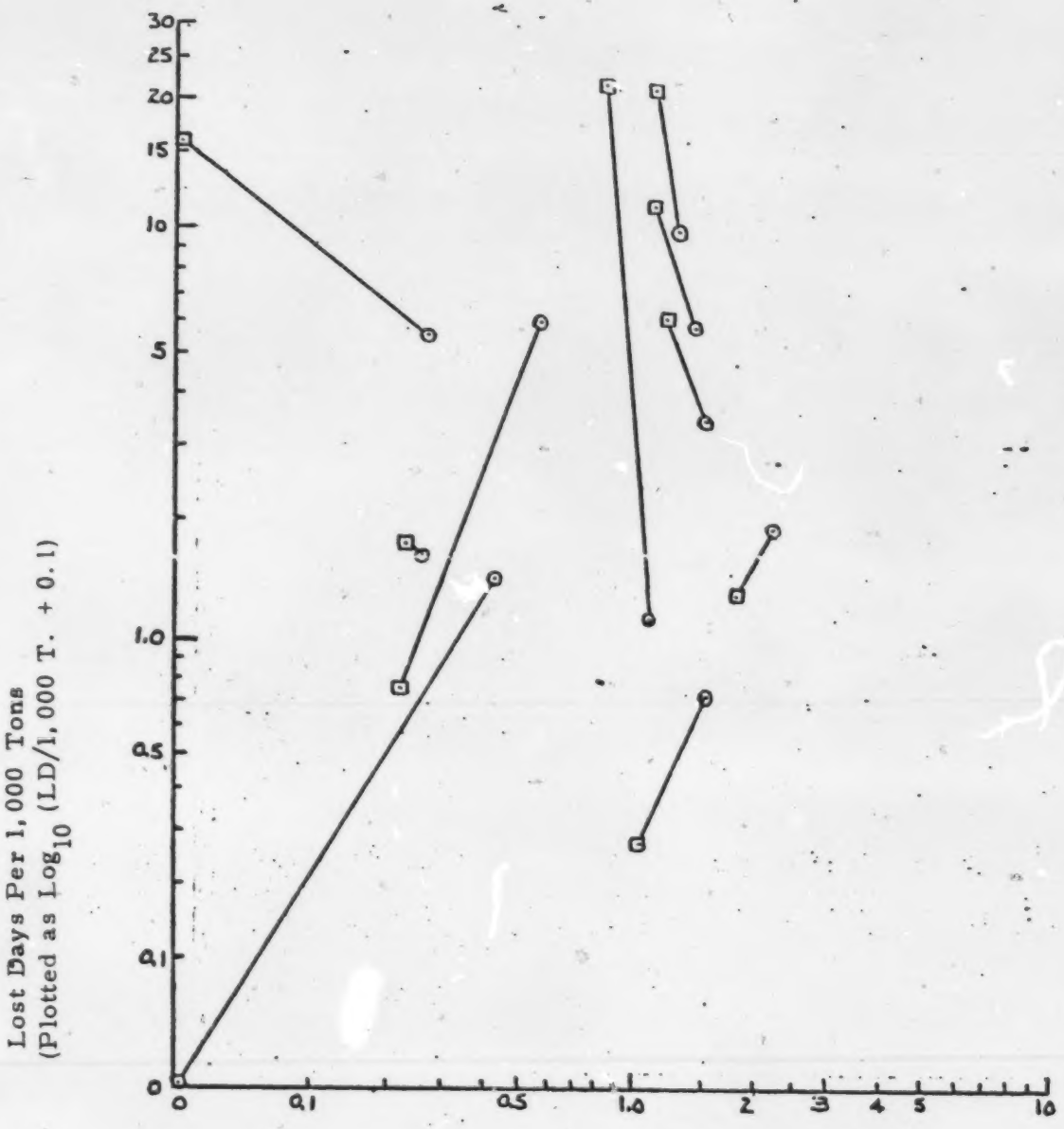


Figure 11

Examples of Decreased Training Rate

- Mid-range increase in training rate (11 cases) --
  - 5 improved lost day rates in 1973 and one stayed at zero.
  - That one (small company) stayed at zero in 1974 and 4 of the other 5 continued to improve their lost day rates in 1974.
  - 5 cases shifted from increase in 1973 to improved lost day rate in 1974.

- Least increase in training rate (11 cases) --
  - 4 improved lost day rates in 1973.
  - 3 of those improved again in 1974.
  - 6 cases shifted from increase in 1973 to improved lost day rate in 1974.

- Decreased training rate (10 cases) --
  - 6 increased lost day rates in 1973.
  - 4 of those 6 increased again in 1974.
  - 8 of the 10 had higher than average lost day rates in 1974.
  - The other 2 cases are one large company whose safety training does not appear in the MESA data and a small company that went from two minor to zero injuries.

An improvement to the lost day rate that corresponds to increased training rates is almost twice as likely in the following year. As noted earlier, part of that improvement must also be attributed to training in the following year, but for purposes of identifying cases of effective and ineffective training using a time lag seems to be appropriate. The changes plotted in Figures 3 through 7 and why the training appears to be more or less effective can be seen by placing 1972 training versus 1973 lost day rates and 1973 training versus 1974 lost day rates on the same cross plot (Figure 8). Connecting the two points as is done in Figures 9 through 11 shows the changes plotted earlier on Figure 4. Figure 9 gives the 26 examples of effective training that appear in the upper right hand quadrant of Figure 4. Figure 10 gives the 7 examples of increased training and increased lost day rate appearing in the lower right hand or "ineffective" quadrant of Figure 4. Figure 11 shows the 10 decreased training cases where 6 of the 10 had corresponding increases in their lost day rates and only 2 had better than average decreases in lost day rate (improvement).

These plots indicate that there is variation in the effectiveness of overall training as reported to MESA, and that increasing or high training levels tend to correspond to improving and low lost day rates. There may still be some question of demonstrating that a causal relationship exists as well as the need to consider injury rates both during and in the year after the training being evaluated. The next section will seek to deal with the latter question. Still another problem is the fact that many mines with virtually identical training programs fall into both effective and ineffective groups. This could mean that the program characteristics may no. have much bearing on effectiveness.

Annual Evaluations of Total Injuries Per Million Man Hours Versus Total Employee-Courses Per Million Man Hours

Grouping the various approaches to training miners into effective and ineffective sets for comparison on the bas.s of annual changes and a one year lag between training and injury rate was not completely satisfactory. Some cases are neither clearly effective nor ineffective, cases of decreased training are excluded, the level of training and injury rates is not considered, and only one of three periods of training (1973) in the available data is being evaluated. In order to overcome these objections the following questions were asked about each mine, company, and division training rate for 1972, 1973, and 1974:

- Did the training rate increase or decrease from the prior year?
- Where the training rate decreased, was it above or below the three year average, or was it zero?

Equal weight was given to increased and above average training rates. Below average training rates that were decreases were given partial credit for improved or low injury rates, but no training at all received a zero score. The scores given each year's training depended on answers to the following questions about injury rates:

- Did the following year's injury rate increase or decrease from its level in the current year for the training being evaluated?
- Where the injury rate decreased, was the injury rate of the current year above or below average?

- Where the injury rate increased or did not change, were both injury rates above average, both below average, or was only the current rate below average?

Decreases to injury rates that were already below average for that organization should be hardest to achieve and were given greatest weight. Increases to above average injury rates are defined as ineffective and were given a negative score. An increased injury rate that was still below average was given a partially effective score. Moving from a below to above average score was given slightly less weight in consideration of the likely contribution of training toward keeping the rate low in the current year.

Training in 1972 was scored as if it was a decrease in order to give different weight to above and below average rates. For 1974 training (1973 in some other cases) no change of injury rate is assumed and the score is based entirely on the current injury rate. Scores of 10, 8, 6, 4, 3, 0, -3, and -5 were possible for each year of training. An average score or "effectiveness index", EI, was calculated for each mine, company, and division. A second score for each aggregate unit was also calculated from the scores of its component mines. The distribution of these average scores for companies and divisions by company type is given in Figure 12.

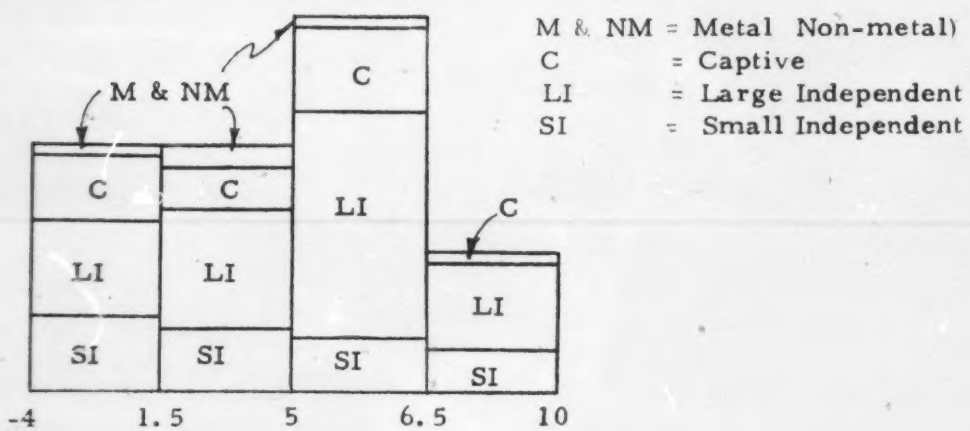


Figure 12

Distribution of Average Annual Training Effectiveness Index Scores by Company Type

Such a ranking of mines, companies, and divisions should be more accurate than an evaluation on the basis of two sets of annual changes to the training and subsequent injury rates. The results were much the same, however, except for having a range of possible scores instead of just two effective and ineffective categories. Nor do comparisons of training approaches between the top and bottom portions of the range appear more fruitful. Mines were located in the top and bottom quartiles for 17 of the 24 companies or divisions of 5 or more mines. Part of this might be explained by differences in other conditions at those mines, but it is not possible to control for such factors with the existing data sets. Some differences between the most and least effective training were found, but first a more rigorous approach to ranking the effectiveness will be briefly noted.

Quarterly Evaluations of Total Injuries Per Million Man Hours Versus Total Employee-Courses Per Million Man Hours

A quarter by quarter study of the overall training and injury rates was conducted to see if a lag of one, two, or three quarters might be more appropriate than one year. The use of up to eight evaluation points rather than three might be less subject to artifacts of the evaluation logic. Also the first and last periods can be deleted without recourse to special assumptions needed to force a score. The logic was again based on the same two questions about the change and levels of the training rate as were used for annual evaluations. Then the injury rates were checked to see if:

- The injury rate in the next quarter was an increase or decrease?
- For increased injury rates, was the next quarter's level above or below average for that organization?

A count of the sequence of changes over four quarters was made to see if any particular pattern is dominant. Over four quarters there are eight possible sequences for either training or injury rates. The eight by eight matrix relating the sequences for the two rates is shown in Figure 13. The total number of four quarter sequences in the data sets is just under 1,200 since there are up to seven for each of the mines. With just a few exceptions the distribution of sequences shown in Figure 13 is nearly random.

Injury Rate Change Sequence	Training Rate Change Sequence								
	+++	++-	+--	+-+	-++	-+-	--+	---	Row Total
---	1.3	1.7	1.0	4.0	0.7	2.0	3.4	1.0	14.8
--+	0.0	1.7	1.3	5.4	1.3	1.7	2.3	0.0	13.8
-+-	2.0	1.3	1.3	4.0	2.0	4.0	3.0	0.7	18.1
-++	0.3	0.7	0.7	1.7	0.3	1.0	2.3	0.7	7.8
+-+	1.7	3.0	1.0	3.4	2.3	1.0	1.7	0.7	14.8
+--	1.0	2.3	0.3	3.4	1.7	2.0	4.4	0.7	15.8
++-	0.3	1.3	1.7	2.3	0.7	1.3	2.0	0.7	10.4
+++	0.0	1.0	0.3	1.0	0.3	1.3	0.3	0.3	4.7
Column Total	6.7	13.1	7.7	24.5	9.4	14.4	19.5	4.7	

Figure 13

Patterns of Changed Injury and Training Rates*

Increased, decreased, and then increased training rates (+-+) stand out as representing almost a quarter of the sequences in the training rate time series. The sequences of injury rate consisting of 2 or 3 decreases that make up more than half the column total here are a sign of generally positive results associated with increased training. Improved injury rates may lead to a decrease in training as well as the opposite causal relationship in which high training rates or increases follow increased or high injury rates. However, the fact that one injury rate sequence (+-+) is the highest cell percentage in the matrix rather than the (+--) sequence also indicates something about the influence of injury rates on training. From the perspective of the influence of injuries on training the percentages of Figure 13 show that a two quarter sequence of decreased injury rate goes with a lower training rate in the second quarter. This can also be observed in data for training by objective category versus injury type. An implication of this could be that an increase of injury rate is more likely to follow decreased training by one quarter than the reverse (namely, decreases of injury rate in the quarter following an increase in training). Low injury rates seem to represent unstable situations requiring essentially steady pressure from training and other safety activities if they are to stay low.

* Percentage of total four quarter sequences are shown in each cell. Not all totals check due to rounding to nearest tenth.

The criteria selected for evaluating a quarter's training on the basis of the next quarter's injury rate give a score of 10, 8, 6, 4, 3, 0, -3, or -5 for each quarter except the last. In most cases this would be nine quarters whose scores were then averaged to obtain an effectiveness index for 179 individual mines, shops, and preparation plants, plus 67 company or division aggregations (56 are mutually exclusive). Figure 14 presents the distribution of individual unit training effectivenss indices by company type. Each score was compared with the results of the annual evaluations. Ten cases were found in which the ranking had changed between the upper and lower quartiles. Another 15 cases had differences that amount to the span of their quartile. Company and division aggregate scores were essentially unchanged.

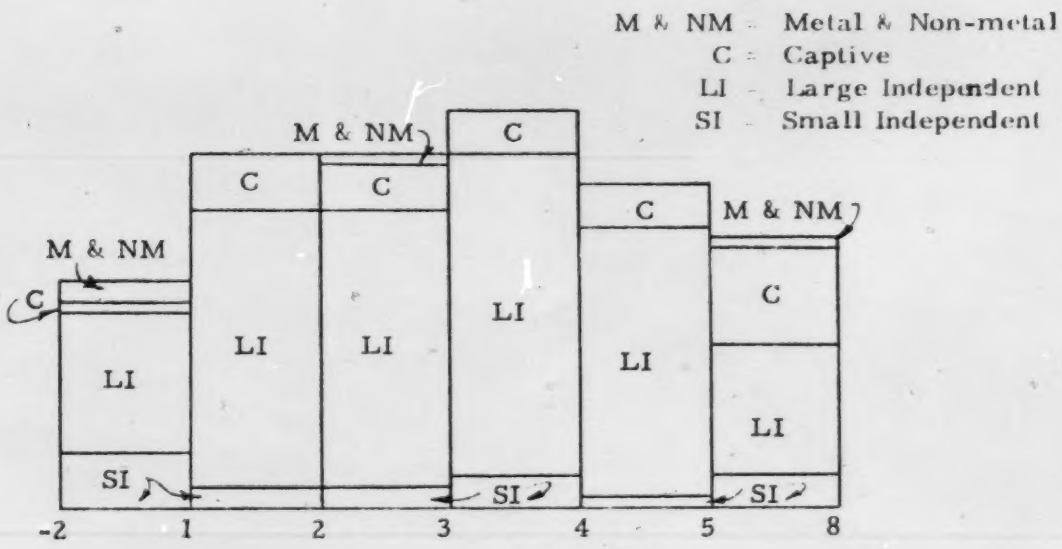


Figure 14

Distribution of Quarterly Training Effectiveness Index Scores by Company Type

Company type distributions in the quarterly evaluations seem to indicate that the steel company (captive) operations tend to rank toward the mostly effective end of the range which differs from the annual evaluations. The highest percentage of small independents appear in the lower half of the range as shown in Table 2, another shift from the annual results. The percentages in this table show both the state and company type distributions between the upper and lower half of the effectiveness index ranges for annual and quarterly data. Other than the states having only a few mines in the sample, the highest percentage tending toward low or high is the 67 percent of the Kentucky mines tending high according to the annual evaluations. Overall, no particular type of company or state appears to hold the key to effective training.

TABLE 2

LOWER AND UPPER HALF PERCENTAGES BY COMPANY TYPE AND MINE LOCATION

Annual Number	Lower Half Annual	Lower Half Quarterly		Upper Half Annual	Upper Half Quarterly	Quarterly Number
57	58	37	Captive	42	63	27
186	46	49	Large Independent	54	51	132
31	74	56	Small Independent	26	44	16
4	75	75	Metal/Non-Metal	25	25	4
2	100	100	Alabama	0	0	1
3	100	0	Colorado	0	100	1
34	46	47	Illinois	54	53	15
3	0	33	Indiana	100	67	3
33	33	41	Kentucky	67	59	29
2	50	50	Michigan	50	50	2
11	36	45	Ohio	64	55	11
58	60	56	Pennsylvania	40	44	34
1	100	100	Tennessee	0	0	1
4	100	25	Utah	0	75	4
33	63	60	Virginia	37	40	33
94	50	42	W. Virginia	50	58	45

Some companies or divisions having very good aggregate evaluations may have several mines ranked rather low for training effectiveness. Part of the mines training at a high rate, rank low in contrast to some with training rates well below average that seem to be quite effective in the training they are doing at a low rate. Much of this can not be explained by the analysis of the existing aggregate data. There are, however, a few other characteristics of the mines and their training programs which can be compared.

In the 1974 data obtained from MESA, the instructor's social security number was listed. Counting the number of instructor's being used and dividing by the employment (potential trainees) provides one training program characteristic for comparison of effective and ineffective programs. The result of this comparison for the top and bottom ten mines of the quarterly effectiveness ranking shows that employee-to-instructor ratio could be an important factor. The average employee-to-instructor ratio in the top ten mines is 23:1. For the bottom ten mines that ratio goes up to 64:1. Not one mine in the top ten has a ratio above the 64:1 average of the least effective programs. Only two of the bottom ten have a ratio lower than 23:1. This does not say anything about who the instructors are, who they work for, how often they conduct classes, etc., but it may uphold the classic theory that the lower the student to teacher ratio, the more effective the classroom situation. This also may well indicate something about the general level of effort going into the tra ning program and the returns in reduced or continued low injury rates.

A second comparison between the top and bottom ten mines was also derived from the basic input data. The question here concerns the mix of course-hours between several categories of training objectives. The most effective training programs are expected to have a larger portion of their effort in the categories of courses for ground control, haulage, machinery, and general accident prevention and less in the categories of mine atmosphere testing, first aid, and mine rescue in the distribution of course-hours than would less effective programs. This expectation was based on the results of evaluations of each of these training categories in terms of the corresponding accident types. These accident

prevention categories of training were found to be very effective in reducing injury rates. Table 3 indicates that if there is any discernable difference in the mix of program effort, it is the bottom ten mines on the overall effectiveness ranking that tend to emphasize the accident prevention courses. While this seems to be a contradiction, a possible reason for this result can be found in the identity of the 20 mines. Seven of the top ten belong to large companies that use their own programs to stress awareness of job hazards and safe work practices through job safety analysis and accident prevention training procedures. This is true of only three of the bottom ten mines in the overall effectiveness ranking. Two of the ten also reported no training in the MESA courses of the accident prevention categories. The percentages in Table 3 also demonstrate the disparity that exists between effort reported in the optional areas of accident prevention and the mandatory training categories. An average duration of 50 hours for electrical qualification/requalification makes the course-hours in this category very high relative to the percentage of electrical type injuries. The other very high percentage of effort comes in the first aid/mine rescue categories and is indicative of the fact that reported training largely consists of activity needed to remain in compliance rather than an accurate representation of all training effort.

TABLE 3

TRAINING PROGRAM EFFORT DISTRIBUTION*

Training Category	Ten Most Effective Training Programs	All Mines	Ten Least Effective Training Programs
Accident Prevention	5.6	4.9	7.4
Electrical Qualification	38.3	50.0	36.0
Mine Ventilation / Atmosphere Testing	16.3	15.0	10.5
First Aid/Mine Rescue	35.0	26.0	42.1
Mine Law/Safety Program Administration	4.7	3.6	4.0

* Percentage of total training hours.

Training Objective Categories Versus Injury Types

Cross-sectional tests of annual aggregations of training in the several categories defined earlier and total injuries or specific injury types were carried out in a search for systematic relationships between training rates in various objectives and corresponding injury rates. These tests found that:

- No category of training was associated with adverse results.
- The relationship between total training rate and total injury rate for the 180 mine sample was weak at best.
- Any evidence of a stronger, causal relationship would need to come from time series analyses of specific training objectives and injury types.
- The mix of training objectives seemed to be biased toward general topics that are not accident causes.

Continued work with the time series data for total training and total injuries described in the previous sections did not seek to demonstrate that overall training has any causal linkage to injury rates. It was assumed that this would be at least partly true for mostly effective training and not true for training that fails to satisfy the definition of effective. All mines in the data set were ranked on an "effectiveness index" according to this basic evaluation criteria.

Work on evaluation of the several categories of training objectives began by consideration of thousands* of plots from the annual time series 1972, 1973, 1974 (first half). There was no new information obtained that was not disclosed by the annual cross sectional tests. The set of plots was repeated with data aggregated by quarter with the clear indication that there are many examples of effective and ineffective training, given the definition of effective that requires a decrease of injury rate in the next observation (year or quarter). When dealing with a specific training objective category and injury type (e.g., ground control and roof or rib fall injuries), it is apparent that the non-zero values in a quarterly data set seldom exceed ten percent. Therefore, the analysis set aside all but the mines having both injuries and training within the ten quarters 1972 through mid-1974.

* Essentially 25 cross plots of rate vs. rate, change vs. change, rate vs. change, and change vs. rate for 17 pairs of measures of training and injury or severity rates and the $\log_{10}$ (rate + 1.0) from six data sets. The 17 pairs of measures were selected from review of plots of 120 pairs of measures in eight cross-sectional data sets.

The analysis concentrated on cases where the mine had a problem (injury rate) and apparently tried to solve it (by training). This does not mean that mines which were either lucky, careful, or lax in reporting did not have the problem or its underlying causes; nor that those that had an injury problem but apparently did not seek a training solution (sometimes not in compliance) are not important. These cases just do not offer any information on the value of training. Training reported in the accident prevention categories that is not mandatory does tend to be a reaction to high or increased injury rates. More important are the facts that:

- Training leads to a reduced injury rate in a manner very strongly different from cases where the training solution was not followed.

- Training in the aggregate sense holds an injury rate down if repeated at six month intervals.

- The cases of effective training by objective category versus injury types correspond very closely to the findings of the overall annual and quarterly evaluations.

The basic findings of these analyses are summarized in Table 4. Effective in this table means a simple decrease to the injury rate for the next two quarters. The evaluation is "unclear" when training continues in the next quarter, the injury rate was at and stayed at zero, or the time series ends. An ineffective quarter is when the injury rate in question continues to increase.

TABLE 4
TRAINING CATEGORIES VERSUS INJURY TYPES

Training Category/ Injury Type	Total Quarters	Training Quarters	Effective Quarters	Unclear Quarters	Ineffective Quarters
Ground Control/ Roof & Rib Fall	1,310	459	138	290	31
Haulage Acc. Prev. / Haulage	530	101	39	56	6
General Acc. Prev. / Lift/Pull & Slip Fall	1,150	308	94	169	43
Electrical Qual. / Electrical	770	237	60	168	9
General Acc. Prev. / Handling Materials	1,020	265	75	169	21
Machinery Acc. Prev. / Machinery & Hand Tool	220	29	8	19	2
Exp. Safety & Methane Test/Explosions & Ignitions	240	103	26	74	3
General Act. Prev./ Total Injuries	1,260	320	109	161	50
No General Acc. Prev. / Total Injuries (Control Group)	320	320	82	167	71

The distributions observed for all but the control group for general accident prevention and total injuries could occur by chance alone less than one time in a hundred. A random distribution would have placed half the training quarters in the unclear column and the other half evenly divided between the effective and ineffective columns. This is almost exactly the distribution for a control group where general accident prevention training was not given at all. This seems to be very strong proof of the value of accident prevention training (both specific and general) when it is employed. The percent of quarters in which these categories of training were employed provides some insight into how often this training tends to be given. The percentages range from a low of 13 percent for the machinery category to 43 percent for explosives safety and methane testing courses. Ground control training and electrical training are the next highest at 35 and 31 percent respectively. From these figures one could expect a typical mine to conduct training in methane detection twice a year. The other two categories of mandatory training are most likely to be given every three months. This corresponds to another finding from this analysis: that injury rates tend to increase after two quarters of decline unless the training is repeated. Table 5 give an example of this finding by listing how many quarters after training the haulage injury rate stays below the rate prior to training. Haulage is used for this example because the training tends to be repeated every fifth quarter and thus has a low number of unclear quarters.

TABLE 5

DURATION OF TRAINING EFFECTIVENESS

Number of Quarters (n) After Training Quarter (Q_i)	Number of Cases Where Injury Rate$_{i+n}$ < Injury Rate$_i$
1	22
2	15
3	11
4	7
5	9
6	2
7	3
8	1

Analysis of individual miners training and injury records might offer a more valid indication of retraining requirements, but it is reasonable to expect that the impact of effective training will go beyond the individual miners. Going back to the ten most and ten least effective training programs gives some indication that this is a valid expectation. The most effective mines conducted training in no less than eight of the ten quarters and in an average of nine quarters. The average for the ten least effective programs is only 57 percent of the ten quarters compared to 90 percent in the ten most effective programs.

Table 6 and Figure 15 offer additional indications of the relatively low emphasis on the accident prevention categories of training, the need for this training, and the potential returns. The number of mines which had both injuries and training, training only, injuries only, and neither injuries nor training in each category are shown in Table 6. The largest numbers for training only appear for the mandatory topics of methane

TABLE 6
COMMONALITY OF INJURIES AND TRAINING

Training Category/ Injury Type	Number of Mines Having: Both Injuries & Training	Training Only	Injuries Only	Neither
Exp. Safety & Methane Test/ Explosions & Ignitions	24	146	1	9
General Acc. Prev./ Total Injuries	126	1	47	6
Ground Control/ Roof & Rib Fall	131	21	0	20
Haulage Acc./Prev./ Haulage	53	7	79	37
General Acc. Prev./ Lift/Pull & Slip/Fall	115	13	39	14
Electrical Qual./ Electrical	77	65	14	23
General Acc. Prev./ Handling Materials	102	24	33	22
Machinery Acc. Prev./ Machinery & Hand Tool	22	0	131	28

testing, electrical qualification and ground control. The optional course categories reverse this pattern in that 43 and 73 percent of the mines did not train in the haulage and machinery accident prevention categories respectively while they experienced that type of injury. While only 9 mines had injuries from fall of roof or rib and no ground control training reported, an average severity of 120 lost days per injury makes the potential returns from ground control training quite high. Approximately half of the lost days for these mines came from roof and rib fall injuries. Figure 15 gives a curve representing the most likely trade-off between training hours and lost days per 1,000 tons for ground control training and roof and rib fall injuries. It was developed from company and division aggregate data for the 1972 training versus 1973 injuries and 1973 training versus 1974 injuries where the training was clearly effective. The dashed straight lines show average observed values for 7 companies with above average rates in 1973, 10 companies with below average rates in 1973 and all 17 effective programs. The solid straight line is the average for 8 ineffective programs. Companies whose training rates decreased in 1973 are not considered. End points on the curve are fixed at the two extreme observed values. On the basis of this curve a mine having an injury rate giving one lost day per 1,000 tons could expect to reduce that rate to one lost day per 10,000 tons by investing in only 4 to 5 employee course hours of effective training for every 10,000 tons of production. That example means less than a man day of time spent in training returns more than a nine day reduction of lost time.

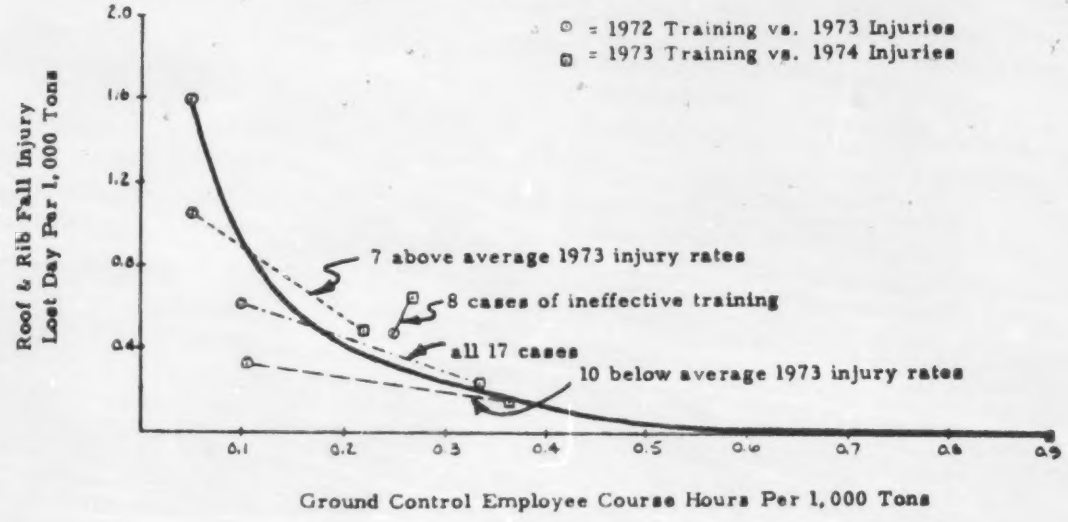


Figure 15

Trade Off Between Lost Days and Course Hours

Since the relationship is not linear (as indicated by the differences between the slopes of the observed average values) the greatest returns come for mines having the greatest problem. Reducing the lost day rate in this example from one per 10,000 tons to one per 100,000 might require 100 effective employee course hours to gain the next nine day saving in lost days. The most important point seems to be that relatively small investments in training can have major returns for the mines having above average injury or lost day rates, if the training is effective. That mine management appears to make training effective rather than any particular training technique was shown by the following comparison of most and least effective programs.

In an effort to control for the likely impact of inspection activity on the safety records some data on cumulative assessments were included in the comparisons of the most and least effective training programs. The cumulative amount of assessments through 1973 was divided by 1972 through mid-1974 exposure to provide a rate measure enabling comparisons between different sized operations. The ten mines rated as having the most effective overall training were assessed an average of $43,000 per million man-hours compared with an average of $64,500 for the 99 mine sample and $125,840 per million man-hours for the least effective programs. This means that effective training comes in mines that tend to comply with all safety standards as well as training requirements. These are safe, well managed operations that are improving in contrast to those that do as little as possible with no apparent impact on safety. The assessment rates were also plotted versus the percent change in injury rate from 1972 to 1974 and the 1972 through mid-1974 average injury rate. These plots are shown in Figures 16 and 17. These plots indicate that safety is not related to how much a mine was being penalized for violation of the safety standards. If anything, the cases of greatest assessment rate tend to show the least improvement (with the exception of two mines that closed in 1972). It would seem that the assessment rate corresponds more to failure to improve safety records than to subsequent reductions to injury rates. This is a significant contrast to the plots of injury versus training rates where the main exception to the desired causal relationship is the large number of cases having both injury and reported training rates at low levels.

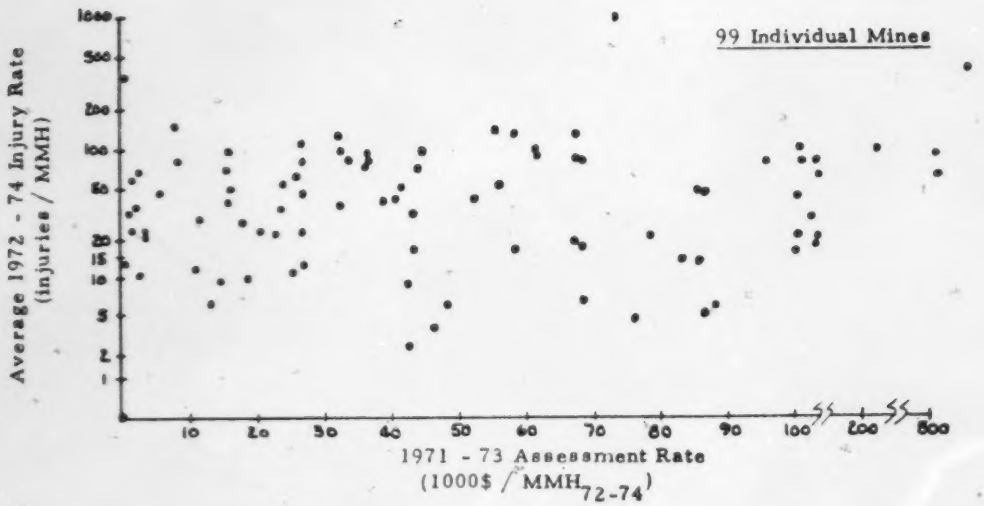


Figure 16

Assessments Versus Injury Rate

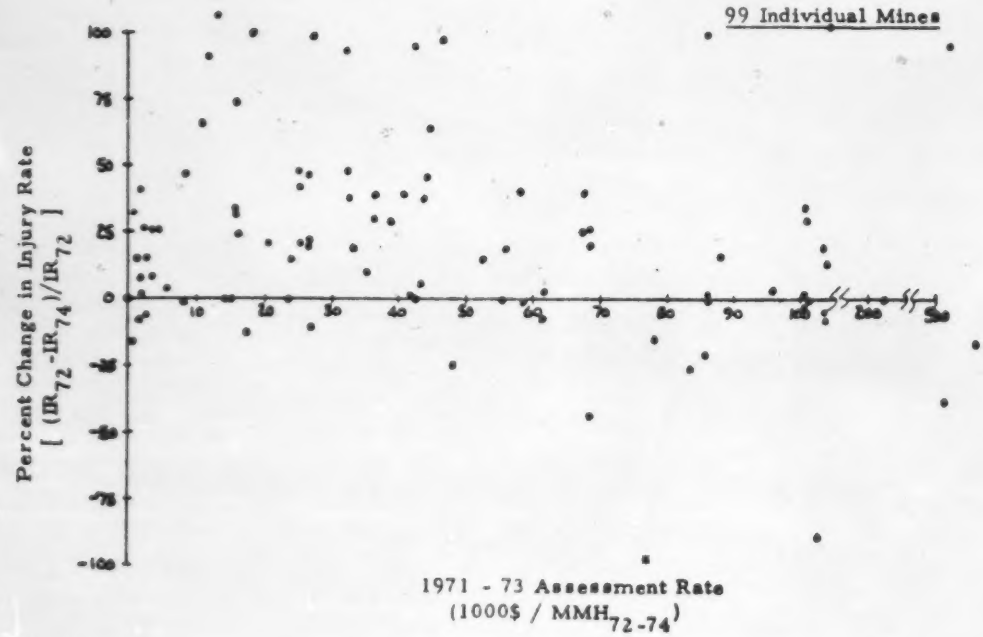


Figure 17

Assessments Versus Change in Injury Rate

CONCLUSIONS AND RECOMMENDATIONS

This research project can be divided into two distinct efforts. A survey of current mining training programs was conducted to produce a general description of the variations of training program characteristics. An evaluation of these training programs was performed to identify the variations of organization, course content, course objective, instructional methods, etc., tend to be associated with low or improving injury rates. It is important to note that the purpose was not to prove that training has caused low or reduced injury rates. Strong indications of systematic effectiveness for some specific categories of training were found, but the main evaluation effort was to use various definitions of effectiveness as the criteria for ranking mines according to the apparent effectiveness of their training. Because these evaluations found essentially all mine and training program characteristics evenly distributed along the range of effectiveness scores, it is not possible to conclude that any particular approach is the best way to train miners. Each mine seems to have a need for training and training resources that depend on the company, mine conditions, mining methods, location, work force composition, and many other factors. The aggregate data and insight into the training process gained during the survey all point to the conclusion that the effectiveness of the training depends on the skill with which the available resources are applied to the perception of the need for training. When that need is limited to doing what training is required by law or the company, the training is not likely to produce more than the required paper work. On the other hand, miners seem to respond positively to programs they see as the result of the operator's interest in their safety and working conditions.

The strongest statistical evidence that training leads to reduced injury rates was found for the training in the roof and rib fall, haulage, electrical, machinery, and general accident prevention categories. This corresponds to the opinions provided by MESA and mine operator training officials. This training is being stressed by MESA in the mines having the highest injury rates and is the heart of several company developed safety programs. In spite of this emphasis and recognition the various courses in accident prevention are a relatively small portion of the total reported training effort in the data studied. There are two reasons for this. Much of this training is part of more comprehensive programs that are not reported. This training, except for ground control and electrical, is not mandatory so it is not conducted at the rate reported in the mandatory topics. Thus, it should not be surprising to find that this training carried out with the

specific objective of improving safety is most likely to achieve that end.

Training in explosives safety, mine ventilation, and methane detection categories is more difficult to evaluate. The catastrophic nature of some explosions or ignitions makes it easy to recognize why these categories of training represent 15 percent of the total reported training hours and 40 percent of the employee-courses. The fact that this type of injury was infrequent in the data analyzed indicates that the training may be achieving the desired result. Out of 1,661 valid mine-quarters studied, these categories of training were given in 891 quarters and there were explosion/ignition type injuries reported in only 49 quarters in 25 of the 170 mines. One of the 25 mines reported no training in these categories while there was training reported in 103 of the 240 quarters for the other 24 mines that could be evaluated. Finding 26 effective versus 3 ineffective training quarters would be a good indication of systematic effectiveness except for the fact that 74 quarters were unclear. Part of the reason there were 74 unclear quarters is the large number of consecutive training-quarters, but another part of the reason could be that lack of knowledge in the use and handling of explosives, methane detection, and mine ventilation is not the major cause of explosion/ignition type injuries. The training might be more relevant if the knowledge or skill portions were part of a more comprehensive program focused on the reasons why the knowledge and skills are not consistently applied on the job.

Training in the categories of first aid , mine rescue, mine law, and safety program administration also represents a large portion of the reported training effort even though it does not directly address accident causes. This training effort amounts to approximately a third of all course-hours and a quarter of all employee-courses because much of it is mandatory, readily available from several sources, and easy to carry out. These observations are not intended to detract from the value of and need for these categories of training. The danger is that these courses have a widespread identification with safety training where the concept of safety does not go beyond the problems resulting from accidents into dealing with the problems that cause accidents. The first answer to questions about safety training in any organization from a mine to a scout troop will often be that first aid training was given recently or is scheduled for the near future. These skills and knowledge are needed, but it is necessary to recognize that they can be accorded undue emphasis with respect to the accident prevention approaches because of this attitude.

The point to be made is that half of the reported training effort (course-hours) and well over half of the training administration (plans, records, reports, certificates, etc.) are going into training that has recognized value, but does not relate strongly or directly to the fundamental issue of reducing injuries to mines. Pending changes to mandatory training requirements and training now required by the UMWA will add emphasis to the kinds of

training that are most effective. The methods by which this training is carried out is not as important to its effectiveness as the way in which the training resources are developed and used. Putting in the required or agreed upon amount of training time will probably accomplish just that - an expenditure of time. Programs adapted to the particular hazards involved in each mine and job in which safety and dealing with mine emergencies is learned right along with the operational skills and knowledge should be the objective, but it may not be one that can be forced on either mine operators or miners. Both need to be convinced of the value of the more comprehensive approach to occupational training.

Encouragement for making safety an integral part of occupational training seems to be possible by some revision to existing administrative procedures for reporting and documenting mandatory training topics. For example, the existing MESA courses include 32 reportable courses that can be applied to the prevention of explosion/ignition type injuries. There are 23 of these that deal with operation of specific devices. Qualified persons whose duties require testing for methane do not have to take all courses, but study of the training data shows that training is often reported on four or more of these courses in a single day. Just one report instead of several would save administrative effort if a report of training on procedures for detecting and dealing with explosive mine atmosphere could satisfy this particular qualification requirement. Since this might be a full day of training there might be objections to an apparent increase of mandatory training time. One report, record, and certificate for a day of effective training seems better than four or more reports, records, and certificates for a series of one hour repetitious rituals that are possible now.

Another set of conclusions stems from the finding that the strongest indications of effectiveness are for training that is directed at specific injury types or general accident prevention courses with respect to total injuries. This concerns the existing system for reporting injuries and training in which the analysis was forced to deal with the ambiguous characterization of an injury type such as "explosive/ignition." This particular problem was compounded by inadvertent inclusion of the flame safety lamp and mine ventilation in the same course category as explosives safety while other methane detection devices went into another category. The analysis combined both categories just as does the term "explosive/ignition." The search for linkages between the efforts being made to train miners and reductions in injury rates was seriously hampered by the nature of the accident reporting system. Unfortunately, accidents tend to be reported in situational rather than behavioral terms. For example, an injury involving a roof fall goes into the data as a "fall of roof" type injury, the situation. This

is not descriptive of some behavioral, ergo, correctable cause like failure to properly test the roof, working under unsupported roof, improper temporary support, or failure to correct known roof hazards. Similarly, an injury caused by a shuttle car driver's failure to give proper warning signals, traveling too fast or disregard of some specific safety procedure is currently coded simply as a haulage accident.

Since the actual behavior that resulted in an injury is often not recorded by the accident report one can only make rather crude assumptions regarding the type of injury one might reasonably expect to be reduced by each reported category of training.

Since the actual behavior that resulted in an injury is often not recorded by the accident report one can only make rather crude assumptions regarding the type of training one might reasonably expect to have some impact upon injuries within each reported category.

In order to conduct useful and continuous monitoring of the need for training and its effectiveness with regard to injury rates, there is a need to more closely link the accident and injury reporting systems. It is also necessary to establish this connection on the basis of behavioral as well as situational phenomena toward which corrective actions (including knowledge, skills, and safety training) can be directed and their results monitored. Current reporting mechanisms could be modified to meet this need and at the same time be reduced in complexity and cost of operation. Time and money being spent on processing of training and injury data by both mine operators and MESA can be reduced and the utility of the resulting data base greatly enhanced.

In so far as possible, all accidents and injuries should be reported in terms of the specific behavioral causes or conditions subject to change through modified work practices, mine conditions, or mining equipment. Training could then be reported as hours of instruction on the prevention of some injury causing action or condition. The present 120 course codes would no longer be needed. They would be replaced by combinations of codes descriptive of injury and training characteristics. A study should be conducted to develop and test such a revision to the reporting system. It should be possible to make the system convey most of the information

now reported in order to maintain continuity in the statistics during a transition period if necessary. The allocation of both training and administrative effort would more closely match the injury problems.

The recommended accident and training reporting system could be based on the use of punch cards on the order of those used in some voting and test scoring systems. These card report forms should be printed in the form of easily answered questions. They could be completed by mine company and hourly personnel for accidents, "near misses," and observation of unsafe conditions or practices. This might sound like opeing a "Pandora's Box," but is really no worse and probably more effective than existing "hot line" arrangements. If the cards could be read directly into the Denver Data Center computer files from remote card readers at district offices much of the administrative effort would be reduced. Coding and punching of data from multiple copy report forms would be eliminated. Various data retrieval programs could be used at the district or sub-district level terminals to tabulate injury and training activities since some convenient date, such as the last inspection. These tabulations could be used by mine inspectors to provide guidance for each inspection tour. Training Center directors and instructors would use the same type of tabulations to monitor and assist with each mine's training program. Training program efforts seem to suffer from a lack of relation to needed behavioral change. In larger part this may be due to the nature of the training requirements. Efforts to meet minimum hours in specific courses consume time, capital and energies that otherwise could be directed toward correcting dysfunctional behaviors identified by the recommended reporting mechanism.

Bearing in mind that the original purpose of required training was to reduce accidents and injuries and not to just increase or maintain training levels, a company having a lower than average injury record could be permitted to conduct whatever training it believes to be needed. On the other hand, a company having a higher than avarage injury record could be required to develop and implement, subject to MESA approval, programs designed to meet its specific needs for accident reduction. The company would have the responsibility of identifying, with MESA's assistance through inspection and feedback of interpreted injury statistics, their own safety problems that are causing the above average injury rates. Once specific problem areas were identified, the company could obtain further help from MESA in the form of training and training materials which the company specifically tailor to meet the needs and conditions in each mine as indicated by inspection and analysis of trends in injury statistics.

Small packages or modules on safe job performance under a variety of specific conditions should be prepared by MESA and made available to the companies that want to improve their training programs. The content of these materials should be based on data generated by the accident report system, thus making them directly relevant to the behavioral causes of accidents. Furthermore, the content of each topic areas should be directly related to a variety of possible mining circumstances. The material for each topic should be tailored to mine characteristics such as seam height, mining and haulage methods employed, gas conditions and roof conditions. Obviously, some existing material remains universally applicable with no modification. The intent of this recommendation is to make mine operators and miners recognize and deal with their own accident problems. This recommendation comes from discussion with operators and training personnel who indicated that involvement of miners in the development of the training courses for their mine probably brought as many safety improvements as the eventual training itself. Putting the analysis of what to teach and how to use MESA or other resources in that training at the level where the need exists could eliminate the possibility of training for compliance rather than safety.

MESA's current role in the conduct of training should continue, particularly the activities of MESA and state training agencies in helping small companies. The role in training might change from teaching a particular course to helping small and large company personnel learn to draw on Bureau of Mines and MESA prepared material for their own programs.

These materials could range from existing complete courses to short film (or tape) sequences on specific situations and accident causes. Another type of training material is needed to support on-the-job-training. This form of training is the only training many miners ever receive. Even though it has not been as effective as it should as indicated by the high injury rates of new and inexperienced miners, it should also be recognized as the only viable training option in some situations. In these cases greater effectiveness and uniformity of instruction and learning can be achieved by use of self-paced training guides and check

lists for the various learning objectives. These materials would provide some formal structure to on-the-job training and a means for documenting and measuring progress. This progress might be enhanced if it were tied to some of the incentive-reward schemes now used to recognize periods of accident-free work by individuals or work crews. Such a system of rewards for training progress whether for on-the-job or for "classroom" forms of training, would also require some type of proficiency testing. Any expanded form of testing both knowledge and skills would have to be the result of a joint labor-management efforts to go beyond the present agreement that training is needed. That training and the associated safety and career development objectives need to be defined. Then everyone from the workmen to the superintendent might recognize the purpose of training is to their mutual advantage and not just to attain compliance.

The recommended changes to injury and training reporting systems, to training procedures or roles for MESA and other training agencies come directly from the survey and analysis results and partly from the difficulties encountered in the data management tasks. A low ratio of employees per instructor and high levels of emphasis on training for accident prevention were noted as some of the factors that distinguish effective training programs. Training at a steady rate throughout the year also appears as a characteristic of effective training. Mines that were identified as particularly effective in a single category of training also rank high on overall effectiveness indices. All of these factors point to a conclusion that mine management attitude is strongly associated with effectiveness of training. Regulations might be changed to reinforce positive company and mine management attitudes and performance by shifting the target of penalties from compliance with training requirements to the end purpose of mining safety. The mine companies will then be able to lower or eliminate emphasis on administrative and legal procedures such as obtaining or extending waivers, producing cards, challanging notices in court and submitting paper work required to comply with the letter of the law. The problem of identifying the most appropriate role for mine safety training is one that can be solved better by a government, management and labor team than by adversaries in court.